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SEMICONDUCTORS AND THE ELECTRONICS INDUSTRY

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

SEMICONDUCTORS AND THE FUTURE OF THE AMERICAN ELECTRONICS INDUSTRY

MAY 17, 1990

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SEMICONDUCTORS AND THE ELECTRONICS INDUSTRY

THURSDAY, MAY 17, 1990

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:33 a.m., in room SR-253, Russell Senate Office Building, Hon. Albert Gore, Jr., (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Pat Windham, professional staff member and Fiona Branton, minority staff counsel.

OPENING STATEMENT OF SENATOR GORE

Senator GORE. The subcommittee will come to order.

I want to welcome all of our witnesses and guests to the hearing this morning on Semiconductors and the Future of the American Electronics Industry.

Last November, about six months ago, the National Advisory Committee on Semiconductors issued what I and others saw as the most comprehensive overview of the U.S. semiconductor industry ever written. It shows very simply and directly just how far the American position in this strategic technology has eroded.

In the critical area of memory chips, for example, Japan's world market share in 1970 was zero. In 1988 their market share was nearly 80 percent. In its cover letter to the President, the Advisory Committee summed up the situation this way, and I quote:

> The semiconductor industry in the United States is in serious trouble. If this vital industry is allowed to wither away, the Nation will pay a price measured in millions of jobs across the entire electronics field, technological leadership in many allied industries such as telecommunications and computers, and the technical edge we depend on for national security.

The report goes on to document this decline in impressive detail. It discusses the implications of the decline for the rest of the electronics industry, and it makes a rather detailed set of recommendations. The report is an important step toward a national semiconductor strategy.

Our companies do not lack competence in making semiconductors. We invented this industry. But the Japanese, Koreans, and Taiwanese have targeted this sector, given its special help, undercut our firms by dumping chips below cost, and they have denied Americans opportunities in their countries. Our companies do not simply face foreign company competition, they face concerted in-

dustry/government partnerships in Asia and increasingly in Europe as well.

We looked at the report immediately upon its completion, and we had a dialogue, our subcommittee, with the industry and the Administration at that time. But we are taking a somewhat different approach this morning. Six months have passed, time for reflection, time for assessment, time for measuring exactly what the response has been, and time for thinking about what it should be.

So we are going to ask this morning how both American industry and the Bush Administration have responded to this important report six months after the fact. We will ask both industry and the Administration witnesses what steps they now think are necessary to keep America strong in electronics.

The industry's position seems to be clear. The industry feels there is a real emergency here. I do, too. American industry is willing to back up their concern with real dollars. Industry took the lead in forming the SEMATECH consortium in 1987, and Congress matched their investment in that important project. More recently, just this week in fact, IBM and others have taken steps to ensure that Perkin-Elmer's important optical lithography technology stays in American hands.

Does the American electronics industry need to do more to keep a domestic semiconductor industry alive and vital here? Certainly it does. But American industry, it must be said, has not shrunk from that challenge.

Unfortunately, the same cannot be said for the United States Government. Here I exclude our second witness, Dr. Allan Bromley, who although he represents the Bush Administration this morning, has engaged in great personal efforts to deal constructively with this problem. Many of the efforts he has made I know for a fact have not been publicly visible. They have not been written about in the newspapers. But, frankly, the response of the Administration as a whole has been, in my opinion, grossly inadequate and distressing.

Consider what has happened and what has not happened in the six months since the Advisory Committee issued its report on this urgent topic. First, there has not even been a public response from the Administration to the report. Here we have a key industry of the future on the ropes, an emergency situation with the industry leaders saying we need a government response as part of a larger national response, and there has been no public response at all from the Administration.

What kind of signal does that send?

Secondly, the President has spoken in favor of working with industry to develop new basic technologies, but he has yet to announce any concrete actions based on this policy.

Third, the Administration has requested a major cut in the budget of DARPA, the research agency which has done more than any other to keep the United States a leader in technology. And of course it has essentially fired DARPA's chief, reassigned him, but removed him from his position.

At the same time, the Administration has requested only $10 million for the main civilian program to support industry-led research, the Commerce Department's Advanced Technology Pro-

gram. So if the Administration as a whole cares about the semiconductor industry, it has not yet shown that it does.

The Administration's posture has been to repeat a few proposals, such as the capital tax cut and antitrust changes. Some of these proposals may indeed be valuable. They are controversial, but some may be valuable. But whatever you feel about them, they certainly do not add up to a comprehensive or even credible blueprint for keeping the United States competitive in the field of high technology.

Our companies will not stay competitive if the government abandons them. To repeat, the pivotal point is that in today's world of industry/government partnerships companies cannot survive alone when foreign competitors are actually consortiums with risks spread broadly in the societies where they are located in order that effort and capital may be focused on the targeted industry.

On the proverbial level playing field our companies would do fine. But where we face that kind of competition it is simply not realistic to expect them to succeed without a comprehensive and well-focused effort here in the United States.

Will our government stand on the side of American industry? Or will it simply stand by as technological leadership, profits, and jobs move steadily offshore? The stakes are enormous. And these are the issues we will explore this morning.

I have a statement that Senator Hollings would like to have included in the record.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

I am pleased that the Science Subcommittee is holding this morning's hearing. This session is one of several hearings that the Commerce Committee will hold this year on competitiveness and the economic future of the United States.

As my colleagues have heard me say, I believe that the United States has won the Cold War but is losing the Economic War—the global contest to see which countries will dominate the key technologies and industries of the twenty-first century and the economic well-being and jobs those industries will bring. Semiconductors is one of the major battles in that war. In Japan, Korea, Taiwan, and now Europe, companies and governments have teamed up to target the semiconductor industry. We sometimes may dislike the tactics they use, but foreign targeting is the reality with which our country must now come to terms. We must find an American way, consistent with our values, for government to support rather than hinder our innovative companies.

The National Advisory Committee on Semiconductors has issued a comprehensive report, a report that is a major step toward developing an effective national strategy for this important industry. It is appropriate that this hearing be held to review the government and industry response to that study.

I look forward to the testimony of our distinguished witnesses.

Senator GORE. I am very pleased to welcome a distinguished set of witnesses, beginning with Dr. John Armstrong, IBM's Vice President for Science and Technology and today's representative of the National Advisory Committee on Semiconductors. Then we will hear from the Hon. Allan Bromley, Director of the Office of Science and Technology Policy, with the Executive Office of the President. Then from Joe Parkinson, Chairman of Micron Technology in Boise. Then from Dr. Moshe Lubin, President and CEO of Hampshire Instruments, Incorporated, in Rochester, New York. And Mr.

Peter M. Mills, Senior Vice President for Administration with SEMATECH.

Dr. Armstrong, let me say that for your statement and all of the statements this morning, we will, without objection, include your full statements in the record, and we invite you to present summaries. We will hear from all of the witnesses before we take questions, although Dr. Bromley has an important meeting in the White House and will have to leave, so we will keep an eye on the time. And we may break into the flow to get questions to Dr. Bromley in plenty of time for him to leave, but we will try to get through as many statements as possible before we do that.

STATEMENT OF JOHN A. ARMSTRONG, VICE PRESIDENT FOR SCIENCE AND TECHNOLOGY, IBM CORP.

Dr. ARMSTRONG. Thank you very much, Mr. Chairman.

It is a pleasure for me to be here. And as you say, although I am Vice President for Science and Technology at IBM, I am here representing the National Advisory Committee for Semiconductors this morning.

You have summarized many aspects of our report very effectively in your opening remarks, Senator Gore. Let me just remind us all that the National Advisory Committee consists of a group of eight business representatives and five senior members of the Administration. We issued a report, as you say, last November, and we will shortly be issuing another interim report which will focus this time more detail on the state of the semiconductor materials and equipment industry.

Senator GORE. When is that due?

Dr. ARMSTRONG. Well, that will be released I think within the next month or five weeks or so—by the time of our next meeting.

Senator GORE. Please keep us closely advised on that.

Dr. ARMSTRONG. Absolutely.

The report, as you summarized, points out that there is little debate about the serious decline in the U.S. semiconductor industry. I think there is little debate about its causes, although I will mention just a few of those. And our report, we would have viewed, and I believe it is being viewed, as a first step in an agenda for laying out some of the possible remedies.

You summarized the decline in the market share of U.S. semiconductor firms. It is different in different areas of the chip industry, but it is declining overall. And the trends, in our view and the view of the committee, the trends are more serious perhaps than the absolute level of the share at this time. The data is always a year or two old, and the shares are declining, as you know.

Something I would like to emphasize this morning, and which we pointed out in our report, is that not only is the market share, and therefore the revenue and the retained earnings and the ability to invest in new technology, not only is that declining, but the viability of the industry itself is heavily dependent on the industry which provides the specialized tooling and equipment to the semiconductor industry.

And the situation of the American semiconductor materials and tooling industry is, in our view, even more urgent—or certainly as

urgent an issue of national policy and concern in the industry. That materials and equipment industry produces the very specialized raw materials and the very highly specialized tools which are required to make semiconductor chips.

You mentioned in your opening remarks the lithography tools of which Perkin-Elmer's is one example. There are dozens of different types of specialized tools. And in many of those areas the U.S. share is declining.

I should also say that there are some aspects of the tooling industry which are still in fairly good shape in the United States. But the general tendency, again, is serious.

The capital requirements for the semiconductor industry are very large and getting larger all the time. Therefore, the costs of capital and the risk associated with deploying large amounts of capital are of very serious concern to both the semiconductor industry itself and to the materials and tooling industry, which is its precursor.

Senator GORE. A new DRAM plant costs about a half a billion dollars and headed is towards three-quarters of a billion dollars, is that right?

Dr. ARMSTRONG. Yes. Within the next decade it will cost upwards of three-quarters of a billion dollars to produce a state-of-the-art plant. And that question of scale is at the root of many of these difficulties. And if I may say so, it is a natural consequence of the incredible rate of progress over the last 15 years. I mean it is not something sinister, it is nothing that you can make go away about that scale. The scale of investment required to be at the leading edge is snowballing and it has been for the last 15 years, and it will continue to.

Senator GORE. And the amortization periods are getting smaller?

Dr. ARMSTRONG. Yes. The period of time over which such a risky investment must be recouped is shrinking, and is, in any case, a matter of a few years—three to five at the most.

The U.S. semiconductor industry, as you have suggested, has in fact invested and invested substantially over the past few years. Last year, the industry spent some $3 billion on R&D and another $3.5 billion on capital investment. That has strained the resources of these firms, and even with these investments we are being outspent by the competition overseas. At least twice out-spent, in the view of the Committee. The increase in market share of the overseas chip makers has generated sufficiently large revenues and retained earnings to allow them to finance the research and development which is required to stay on the leading edge. There is positive feedback in that system.

Now, why does the loss of market share matter? Well, you pointed out in your remarks, and I think it is worth emphasizing, that the electronics industry should be thought of—the chip industry is part of the electronics industry, which is an infrastructure question for the United States. A healthy electronics industry underlies almost all modern high technology areas of industry, all the way from medicine to computers and aviation and transportation. Moreover, the tools which are built with modern electronics are one of the principal sources of productivity gains, and therefore of increased wealth in our economy.

What can be done about these declines? That is the issue that our report has discussed, that the Committee continues to discuss, and that we will be focusing on this morning. First of all, industry has a major responsibility to shorten its product cycles, increase the speed with which new developments move from research into manufacturing. There has to be an unremitting focus on quality. The view of manufacturing in the United States, the sort of culture of manufacturing, has to be improved dramatically.

These are matters that industry will do, has to do, basically has to do by itself, but they are not sufficient, as you suggest. The business climate has to improve. It has to be easier to make a reasonable return on investment in the semiconductor business in order to take the risks and to make the investments required. Therefore, the availability, the cost and the patience of capital are crucial matters, in the view of the Committee.

The R&D tax credits which the Committee has mentioned in our report and which we refer to is an important matter in our view, and, by the way, it is important to make it permanent, and it is important to make the tax credit apply to the total R&D spending, not to the increment, because the problem of the American semiconductor industry today is not one of an increment in R&D funding, the problem is one of keeping the R&D funding even at a constant real rate. So the tax credit, which is only on the increment—the R&D tax credit only on the increment is not of much use to the industry.

There are modest changes in the antitrust law that would be very helpful, in particular, the rules which relate to market share should be global. They should take account of global market share in appropriate cases. Our Committee recommended increased funding for SEMATECH and SEMATECH has, as one of its principle responsibilities—principle missions—to strengthen the U.S. semiconductor tooling and equipment industry, about which I have been talking.

There are other recommendations in the report which I believe the Committee has. Time does not permit me to discuss them all. I hope some of them will come up during the question and answer period. The semiconductor industry faces a tremendous challenge, as you have outlined. International competitiveness rests primarily in our own hands, the hands of the industry, and in the cooperative arrangements we have with Government.

A point I would like to make which has not come out yet in this morning's discussion is that the time that is available is really quite short. A generation of new technology in the semiconductor field, a new generation comes every three years, and in that period of three years a whole new set of tools, a whole new set of research and development investment has to be made and amortized. The amount of time that is available to change the current decline is measured in the view of the National Advisory Committee in months—months being 12 to 30 at the outside—and we are quite concerned about the shortness of that time scale and therefore emphasize the urgency of the matter as you did, Mr. Chairman.

Thank you very much.

[The statement follows:]

STATEMENT OF
J. A. ARMSTRONG
VICE PRESIDENT, SCIENCE AND TECHNOLOGY
IBM CORPORATION

Good morning Mr. Chairman and members of the Subcommittee. My name is John Armstrong. While I am, as you mentioned Mr. Chairman, IBM Vice President, Science and Technology, I am appearing today on behalf of the National Advisory Committee on Semiconductors.

This Committee of thirteen business and government leaders was formed by Congress and the President in 1988 to develop a national semiconductor strategy. The first annual report, issued in November 1989, contains an assessment of the current state of the industry and recommendations that can serve as the first steps toward a national semiconductor strategy.

There is little debate among the U.S. electronics industry that such a strategy is required, and that aggressive steps towards its implementation begun

immediately. The fact that the U.S. semiconductor industry has suffered a dramatic decline over the last decade is, at this point, well established. The reasons for this decline are varied, and no single effort will undo the losses of the past decade. It is clear, however, that the semiconductor industry must take aggressive, coordinated action, often in cooperation with government, to stabilize and improve its position while there are still areas of significant strength on which to build.

In general, American semiconductor companies have seen their world market share fall from over 60% to under 40% in just a decade. For discreet devices, we have gone from rough parity to 20 points behind Japan. And the situation is truly alarming for memory chips. In 1970, Japan had a zero share of the market. Since then, Japan's share of the world merchant market for memory chips has grown to over 80%. This is particularly significant since technical improvements applicable to other semiconductor products are driven by leading edge memory technology.

This decline in market share of the U.S. chip industry tells only part of the story. While success of U.S. semiconductor manufacturers is paramount, their success will be limited by their ability to obtain state of the art semiconductor materials and production tools.

The semiconductor materials and equipment industry produces the raw materials and manufacturing equipment needed for the production of integrated circuits. This industry is critical to the infrastructure required for a successful microelectronics industry. Yet, this industry -- just as the chip industry -- has suffered serious declines in its share of the world market over the past decade.

Today, 85% of all leading edge manufacturing capacity for submicron semiconductor wafers resides in the Far East. A decade ago, 7% of the top ten semiconductor tool companies were foreign owned. Today, over half are foreign owned, and the trend is continuing. It is for this reason that IBM has joined with other U.S. industry firms and SEMATECH to do what we can to help preserve and strengthen this vital U.S. infrastructure.

This is the reason we intend to take equity positions in, and have provided technology to, the companies that have acquired former divisions of one of our country's strongest semiconductor tool companies, Perkin-Elmer. And while we have every expectation for the success of these new endeavors, alone they will not be sufficient. The factors that have led to the decline of the semiconductor tool and materials industries in this country are worsening by the day.

What are these factors?

First, due to decline of the semiconductor manufacturing industry in our country, the domestic market for the tool and materials industry has been shrinking, with attendant reductions in revenues of those companies. With less revenue to fuel research and development, U.S. companies have been struggling to maintain competitive state of the art products.

Second, just as in the chip industry, the capital requirements for the tool and materials industry are large. And with a comparative U.S. cost of capital roughly double that of our competitors, that burden is only made heavier.

This is not to say that the U.S. semiconductor industry has failed to invest. Over the past year alone, the industry has spent about $3 billion on R&D, and another $3.5 billion in capital investment. And while the resources of even very large firms are strained today by such expenditures, maintaining a leading edge chip technology will become much more expensive in the future.

For example, the cost of one state of the art facility for semiconductor memory chips has risen eight-fold since 1980, from $25 million to $200 million. By the middle of this decade, the cost of a state of the art

manufacturing facility will rise to more than three quarters of a billion dollars.

Even with such high investments, we are being out-spent by our international competitors. The top five Japanese firms currently spend twice as much on R&D and new plants and facilities as the top five American merchant firms. Japanese semiconductor revenues multiplied by a factor of six from 1981 to 1988, while revenues of U.S. producers merely tripled. This huge growth in sales revenues of the top Japanese firms is funding an impressive level of investment in R&D and capital equipment with which to support further growth in Japanese share of the world semiconductor, materials, and tool market.

Why does this loss of market share matter? The bottom line is that the semiconductor industry is vital to a healthy U.S. electronics industry, and a healthy U.S. electronics industry is vital to a healthy U.S. economy. Defined broadly, electronics is the largest industry in our country. It employs about 3 million workers, and produces over $400 billion in products of which $41 billion are exported. It accounts for about 40% of all U.S. patents and conducts 20% of all U.S. industrial research. Moreover, the electronics products and services contributed to productivity gains throughout the private and public sectors.

The national security of the U.S. is directly related to our industry's excellence in semiconductors. Satellites, imaging systems, communications devices, transportation systems, weaponry and most other military devices are dependent upon semiconductors for their operation, their production or both. Even in a world with diminished tensions, we should not entrust our national security to foreign supply of our most critical technologies.

Given the decline in the semiconductor industry and its consequences, the question is: What can be done by industry and government to reverse the trend and rebuild this vital sector? First, American industry itself must tighten the linkages between research, development and manufacturing to streamline the process of bringing competitive products to the marketplace. The focus on incrementally improving existing semiconductor products must be vigilant. Manufacturing must be resurrected from its role as a second class citizen to a pivotal factor in competitive success. These are cultural issues which industry, for the most part, must tackle alone.

But these actions will not be sufficient unless the government acts to improve the business climate in which these changes will take place. It is important to improve the availability, cost, and patience of investment capital. Lower

risk in investment decisions, longer time horizons, and greater immunity from business cycle changes are advantages which result from a lower cost, patient capital investment environment. Reducing the federal deficit, creating tax policies to promote savings, and making permanent the R&D tax credit will be helpful in solving this critical problem.

Second, given the enormous capital investments required in the semiconductor industry, coupled with uniquely high risks, it is vital that Congress act now to extend the 1984 National Cooperative Research Act to include joint production. This modest change to the antitrust laws provides that production joint ventures would be subject to single, rather than treble, antitrust damages. This, together with global analysis of relevant markets when appropriate, would make such ventures a more appealing option when more traditional approaches could not be pursued due to expense or risk.

It would also permit large firms, like IBM, to more easily share its facilities and resources with smaller companies which may otherwise be unable to pursue leading edge technologies. H.R. 4611, with modest changes to its foreign participation provisions, represents an excellent start in pursuit of this goal. I urge this subcommittee to pursue this issue with your colleagues for timely action by the Senate as well, and commend Senators Leahy, Thurmond and Biden for their leadership in this area.

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Third, support of America's semiconductor infrastructure - the tool and materials industry - must be strengthened. NACS has recommended increased industry funding, and matching government investments, for precompetitive research and development in equipment and materials. Increased funding of SEMATECH, which is pursuing this initiative as part of its mission, would be an excellent means for further government participation.

Fourth, the semiconductor industry requires well trained workers, engineers and managers. Competitive performance of this industry is highly dependent on the quality of its workforce. Measures are needed across the entire spectrum of education in our country, from pre-schoolers to graduate students, to produce the well educated workers we need.

I am pleased to say that John Akers, Chairman of IBM and of the Business Roundtable Education Task Force, has been joined by chief executive officers from corporations in every state in our country to address the education crisis. Leadership, involvement and investment by the government must continue as business and government work together to address education at the K-12, college, and graduate school levels.

These recommendations highlight the key proposals from the first NACS report. A complete list of the initial NACS recommendations are attached to my testimony. Some of these recommendations, which time will not permit me to describe, are equally important and I urge you to consider each of them.

In summary, the U.S. semiconductor industry faces tremendous challenges in a difficult domestic and international environment. It is undeniably true that our international competitiveness rests with us. But the majority of actions required to strengthen our industry and improve the business environment in which it operates will benefit from much greater cooperation between industry and government. While the gap continues to broaden between the U.S. semiconductor industry and its foreign competitors, this need not be the case. Members of NACS are persuaded that with timely action by the private and public sectors, the United States can regain preeminence in this vital industry which its companies created a little more than two decades ago.

Thank you. I will be happy to address any questions you might have.

Senator GORE. Thank you very much. Dr. Bromley, we are always pleased to have you as a witness here. I am honored to call you a personal friend as well. I know I speak for the Subcommittee in welcoming you wholeheartedly this morning. This is an area where you have gained a tremendous amount of expertise, and we welcome your views this morning.

STATEMENT OF HON. D. ALLAN BROMLEY, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. BROMLEY. Thank you very much, Mr. Chairman.

I do welcome this opportunity to be here this morning to testify on some very critical issues that the U.S. electronics industry faces, and I agree with Dr. Armstrong that because of the key role that electronics provides in terms of building blocks from which computer and telecommunications systems are assembled and the degree to which the health of our society depends on such systems, this is a matter of vital concern to the entire Nation.

I have testified previously, shortly after the release of the Advisory Committee's report, that I believe that it provides a set of data that document a persistent and serious decline in several major components of our electronics industry over this past decade. These include, as Dr. Armstrong has outlined, businesses in materials and equipment, memory components, consumer electronics, and most particularly in the underlying materials and manufacturing segments that underlie the actual production of electronic components.

The same report also presents the Committee's analysis of many of the factors that they believe have led to this decline. However, I would have to say that I do not believe that a successful overall strategy for our electronics industry can be based only on repairing deficiencies. I think you would agree, sir, that a successful strategy must first and foremost build on and exploit our strengths and our advantages, and there are many.

One of our greatest strengths is the infrastructure for research and development that we have in this country. We have a culture that prizes innovation, a university system that is superior to any, an open and hospitable society that attracts some of the world's best scientific minds, a business climate that encourages innovation—innovative enterprises—and a financial system that allows new businesses to grow quickly into major ones.

Frankly, I would submit, sir, that that is one of the reasons why it is not really surprising that our technology base is still the strongest in the world. We lead wherever innovative technology is more critical than production efficiency. That is the key dichotomy. First and foremost, I think we have to maintain the superiority of our technology base.

It is for this reason that the President just recently, in the March 7 talk to the American Electronics Association, made it plain that he views part of his Administration's responsibility to assist industry, not only the electronics industry but industry generally, in that crucial stage between the original discovery and the development, up through the precompetitive phase, of generic tech-

nologies that are so important to our economic competitiveness and to our national security—every aspect of our society, including education. This is a policy that I must say I wholeheartedly support, and I shall do everything I can to assist in its execution.

But however important the role of technology may be, if we are going to have a successful national strategy in industrial competitiveness we have to go farther. Our strength in technology has not prevented the steady erosion in our market share in electronics, as Dr. Armstrong and the Committee have documented.

As each segment of the business matures, the advantage quickly shifts from the innovative to the efficient producer, and many factors, I would submit, have contributed—and we have heard recently, Mr. Chairman, of some of these—to Japan's success as a producer. None is more important than their persistent, high rate of investment.

Nor is Japan the only example where a high rate of capital investment pays off. I would suggest that it is important for us to keep in mind that Taiwan embarked on an ambitious program of investment in the electronics industry 10 years ago, targeting a national goal of a 2 percent market share at the end of 10 years. They achieved 4 percent market share.

Of course, we should also seek to ensure that foreign industry investment levels are responding to free market forces, just as U.S. industry investment must respond to those forces. In the Uruguay Round of multilateral trade negotiations we are seeking to impose increased discipline on subsidies, because subsidies can induce investments that would not otherwise be commercially viable. I submit, sir, that there is an increasing awareness internationally that serious trade distortions can result not only from export subsidies but from domestic subsidies as well.

Many believe that the decline in our electronics industry can be related directly to a persistent under-investment—that is, a persistent under-investment by companies in the industry—that has occurred over the past decade.

Many factors have contributed to this, and it is quite clear, and I agree entirely, that remedial actions must be taken. The cost of capital must be lowered. Reducing the overall bias against savings and investment in the federal tax code would encourage all investments, including investments in electronics. And nothing, I would submit, attracts investment and capital better than the promise of success. Developments in technology, an improvement in the business climate, and strategic vision on the part of our leaders, both public and private, will all contribute to a restoration of our national confidence, without which success is simply impossible.

Now, the November 1989 report of the National Advisory Committee recommends the establishment of a Consumer Electronics Capital Corporation to promote the capital needed to restore our consumer electronics industry. A substantial Federal role in the form of interest subsidies and loan guarantees is envisaged. Frankly, as I have testified before, I do not support this recommendation, and I say that simply because I do not believe that it will work.

On the one hand, we do not have the funds available to remedy the situation in brute force, and if we had those funds I still do not believe that this particular solution would work. The reason why

the U.S. consumer electronics industry is unable to attract adequate private capital is because the risk of such investment would be very great, and the risk is great because in the absence of an excellent strategy the likelihood of success is not high. The proposed CECC would do nothing to lower that overall risk; it would merely shift the risk from private investors to the taxpayer, and I do not believe that this Administration will accept that particular approach.

The electronics industry will, however, benefit from the Administration's initiative to remove impediments to investment in the U.S. These include measures to increase the savings rate, to restore the capital gains tax differential, and to facilitate joint production ventures.

In conclusion, Mr. Chairman, I believe that the Administration has proposed a number of important initiatives that will have the effect of providing a more favorable climate and a more level playing field for the electronics industry. These include general economic measures such as the capital gains tax reduction, the research and experimentation tax credit—changed as Dr. Armstrong has suggested would be most helpful—and direct Federal investment in generic, precompetitive areas of technology.

There is an appropriate Federal role in these areas. I support it strongly, and it is being actively pursued.

Thank you, Mr. Chairman.

Senator GORE. Thank you.

We are going to shift gears here a little bit. Because we have a number of Senators present, and Dr. Bromley has to depart at 10:45 for a meeting at the White House we will take questions for him now.

I know we have three other witnesses yet to give opening statements, but what I am going to suggest is that we focus our questions now for Dr. Bromley during the next 40 minutes, and then go to the opening statements.

Prior to doing that, I would like to ask Mr. Parkinson, Mr. Mills and Dr. Lubin if in one minute each you could tell us, and through Dr. Bromley, the President, what questions do you think are most important to explore during this hearing?

You can pass, too, if you wish.

Mr. PARKINSON. Mr. Chairman, members of the committee, I guess the question I have would be, when we are going to stop retreating, and start attacking these foreign competitors? And just because we are a targeted industry, I do not believe we should retreat. And I think there is an alternative to the retreat into niche markets, and that we can prevail in these volume markets. And what is going to be the game plan for the attack?

Senator GORE. Mr. Mills.

Mr. MILLS. I will pass, Mr. Chairman.

Senator GORE. I quite understand, Mr. Mills.

Dr. Lubin.

Dr. LUBIN. Yes, I would say two things. I would like to hear from the Administration more concrete suggestions on lowering the competitive cost of capital. And number two, the plans the Administration might have in the transition from innovation, which is clearly

our strength, into efficient production, which gives us the economic strength to press on with continued innovation.

Senator GORE. Dr. Armstrong, you have had a statement here, but do you want to suggest a question?

Dr. ARMSTRONG. I will pass. We will have plenty of opportunity later.

Senator GORE. All right, fine.

I am going to ask the staff to set the clock on five minutes, and we will take perhaps two rounds with Dr. Bromley before we move on to the other opening statements.

Dr. Bromley, the first question suggested by our panel here this morning is when are we going to have a game plan which will allow us to stop retreating and start proactively building our competitive strength in this industry? Why has the Administration failed to respond to this Advisory Committee report? Why has the President not presented any kind of game plan? Does the President care that the semiconductor industry is on the ropes here in the United States?

Dr. BROMLEY. To take the last part first, sir, the President does indeed care. But I would take issue with the first part of the question, that we have not responded at all to this report. In fact, we have been responding.

I, for example, have arranged for meetings with myself, Governor Sununu, and Richard Darman with a significant fraction of the private sector membership of the committee. We met on one occasion for some four-and-a-half hours. We have been discussing ways in which we can work together with the industry to develop specifically the strategies that we both are interested in developing, so that we can move forward to make this a vital domestic industry.

It is not that we are not responding. We are not responding publicly, but we are working as diligently as we can, and very closely and effectively, I may say—with the members of the committee and some other senior representatives from the electronics industry to develop the kinds of strategies that will involve actions on the part of industry, on the part of government, and joint actions. What we are trying to do is to put together a package that draws on the best strengths of all participants so that we can then come forward with a coherent plan.

Senator GORE. I am very impressed, Dr. Bromley, with your personal efforts. I have seen your footprints all over this turf, and heard of your conversations and meetings as you have engaged in a great deal of activity to try to stem the tide. But the impression I have, in spite of the fact that you have been moved over to the West Wing, and you have gained in stature within the Administration, as I expected and hoped would happen, in spite of all those positive developments, still the Administration as a whole, and the President in particular, has been unwilling to actually do anything.

Mr. Sununu and Mr. Darman will meet, and I think that is healthy, they will talk, and I think that is good, but when it comes to putting their money where their mouths are, or in this case where their ears are, they do not do anything. Now that would not matter if the decline of the industry was not accelerating. It is. We need to do something.

I suspect that some of the things you have recommended that they do, they have told you they cannot do. And you are persistent, to your credit, and are continuing to make the case, I am sure, in a most impressive way. But there has not been a single concrete action by the President in response to the Advisory Committee report. You have set up meetings. You have jawboned. You have used the telephone, worn it out, but Craig Fields has been fired, the relevant budgets have been cut, and there has been a deafening inaction on the part of the President.

So can you point to a single concrete action by the President?

Dr. BROMLEY. The situation, sir, is such that we who are advisors to the President are attempting to put together what we believe is an appropriate, coherent, integrated package of activities that would involve a number of the Federal agencies. At that point, clearly that will be part of the President's program. But we have not yet developed that, because we have not had an opportunity—we have not had the time yet, Senator.

We have given our friends in the industry specific homework tasks. They are working on those. They have not come back to us yet with those packages of information that we think are important for us to understand and for them to understand what is the most effective way for us in the Federal Government to help.

We do not debate the fact that the situation is serious, and that there is a role for the Federal Government, but what we want to do is to be sure that the actions we take are designed to be most effective in working with the industry.

Senator GORE. Well, the European Economic Community is investing $4 billion in semiconductors.

Dr. BROMLEY. Yes.

Senator GORE. The Japanese are investing many billions across the board. The Administration has moved you to the West Wing and delivered a fairly well-written paragraph in a speech to the American Electronics Association. I would not be surprised if you wrote it. I do not think there is a symmetry of effort. You have a major effort here, a major effort there, and yet in the United States we have symbolism and inaction.

And if my tone conveys some feeling of frustration, so do the statements coming from the industry, so do the statements coming from the analysts of the industry, the people who spend their lives and invest their fortunes in the hope that the United States of America will get up off the mat and start fighting back and making a genuine effort in this critical field.

And so I do urge that more be done.

Dr. BROMLEY. Mr. Chairman, may I say that I share some of your frustration. And I think that you might wish to hear from Dr. Armstrong about some of the things that we really have been doing, because I would like to dispel this impression that there has been no response and no action taken on the basis of this important report.

Senator GORE. Well, there has been no public response and there has been no visible action. Again, I know you have worked heroically on an individual basis. And I must give the President credit for appointing you and for giving you the license to jawbone and to talk and to be active. And I think it is not insignificant. But, with

all due respect, no matter how talented you are, it is not a match for the concerted efforts by the Europeans and the Japanese.

Let me recognize, in order of arrival, Senator Bryan.

Senator BRYAN. Thank you very much, Mr. Chairman.

Dr. Armstrong, I would like to hear your response. Dr. Bromley indicated that he does not think that this capital corporation that you have recommended in your report can be successful because, as I understand his argument, the risks are high and the potential for failure is great. All this would do would be to shift the risk from the private to the public sector—the taxpayer.

Obviously, your Advisory Committee felt very strongly about it or you would not have included it. Could I get you to respond specifically to the concerns that Dr. Bromley raised?

Dr. ARMSTRONG. Well, first of all, the electronics capital corporation and the interest in it that was shown in our report points to the fact that the consumer electronics industry is a major market for the semiconductor manufacturers. And in the absence of such a viable market in the United States, that is, of domestic consumer electronics manufacturers, our domestic chip producers do not have a market share, which is extremely helpful to their competitors.

So we really do believe that a revitalized consumer electronics industry in the United States, that is to say, American firms playing a major role in that industry, would be a significant help to the semiconductor industry.

Moreover, there is another reason why it is so important, and that is because in such areas as computers, much of the technology which is important in even high performance computing is coming from the consumer electronics industry. It is a remarkable development in the last 10 years. So it is very important to explore options to restart the U.S. consumer electronics industry. And our proposal, and it was just that, was intended to start the discussion on how can we restart the U.S. consumer electronics industry.

The committee has heard from members of the Administration, as Dr. Bromley suggested, some of the objections which he outlined this morning. And we understand that those are serious questions, and the committee is in fact looking further into just how such a corporation would work. That is, we do not take the position that the suggestion that we made in our initial report is the last word on the subject.

So the committee is reconsidering what would be an effective way to restart the consumer electronics industry, how to share the risks. And we appreciate the dialogue and the very candid exchange of views that we have had with the Administration on that matter. And I would say we do not have the last word, as far as the view of the committee is concerned, as to just what the right way to start the consumer electronics industry is.

Senator BRYAN. Dr. Armstrong, it would be my hope that the Administration would abandon this ideological litmus test and look at this thing in a very pragmatic way. Look at this as to how the government can be helpful in jump starting this industry. I think that is what you are, in effect, asking.

Now the criticism sometimes voiced, and I have been among those who have been critical, is that the industry itself, the private sector, has been short term in focus. What can we push to the

bottom line this quarter, as opposed to what kind of long-term R&D investment are we going to make.

What is the appropriate role of the private sector in developing this capital pool?

Dr. ARMSTRONG. Well, first of all, the private sector, as you say, has a major responsibility here. And that investment has to come from retained earnings. And I would say that the evidence is pretty good that companies which have had a pretty good business in whatever piece of this electronics world they are part of, where they have had a pretty good business, there have been very substantial, sustained, ongoing investments by American companies, my own firm included.

The problem is, and it has shown up in spades for the materials and equipment industry, is that a lot of the smaller companies simply do not have the revenue, the market share, and therefore the retained earnings to make these investments, and they are far from being able to raise the capital themselves.

So my comment would be that in the sectors of the electronics industry where American firms still are doing well, and there are a number of those, long-term capital investments are being made. And where market share has been lost, as it has in some of the chip manufacturers and in much of the tooling industry, they do not have the capital to invest.

Senator BRYAN. Dr. Bromley, Dr. Lubin raised a question, and that was, we do quite well and continue to score impressively in terms of innovative technology and approach, but I think there is almost a consensus among those that know anything about this, who recognize that in terms of translating that breakthrough or the innovative approach into marketable products, we do not do well at all. I mean, we have fallen terribly behind in that.

Specifically, again, casting aside all of this rigid ideology, like we do not pick winners and losers. Frankly, recognizing our history, the history of this country is that government has played a role in a very positive sense.

Samuel F.B. Morse came to this very city and said look, I have got a gadget, I call it a telegraph, I think it may work. I need your help in stringing some wire from the city of Washington to Baltimore. The sum in that time period would have been perhaps as astounding as some of the figures we hear today that come out of some of the recommendations that we hear.

Well, the Congress did it. It ended the life of the Pony Express out in my part of the country after 16 months. But it was a technology that in the 19th century revolutionized the world. Why cannot we do some of those kinds of things in terms of the technology that the scientists of the 20th century have that may have equal promise in terms of revolutionizing the way we do things, the way we buy products, and the way we live?

Dr. BROMLEY. I am glad you chose that particular example, senator. It shows what a good Yale man can do when turned loose.

To respond directly to the question, though, I agree with you, sir, we still have international leadership in terms of basic research in almost every area of scientific and technological activity. Where we really come unstuck is when we reach the question of production

and production efficiency. We still do reasonably well during technology development from the basic discovery.

I believe that it is the position of this Administration that we do indeed need to play a much more active role than we have in helping our companies, particularly small companies—get together with Government seed money, with Government help, to allow them to avoid having to reinvent the technological wheel independently in each case. Our competitors are doing that, and if we try to do it the additional cost, the increased risk, the additional time, will make us less than competitive on every occasion. So we really have a major role to play in catalyzing consortia, in bringing together people so that we do not waste time and effort in developing generic technologies that underlie an enormous amount of our economic strength and national security, and yet are such that no single company can be sure enough of recapturing sufficient credit to justify their individual investment at the level necessary. That is where we really have a role to play.

We also have another role to play, and I would submit that the Administration thinks that it is much more than a slogan. We do not believe that we are smart enough in the Administration to do a better job of picking the winners and losers in the production phase than is the private sector.

However, I think that we have a very important national problem here, and it comes back to a very simple, basic fact. We have tended over the last several decades to focus our attention, our reward structure, everything else, on the very large development, the Noble Prize-type development that revolutionizes production, that revolutionizes manufacturing, that revolutionizes the development of attractive goods and services. We have tended to forget the tremendous importance of the evolutionary development, the small change on the production line, that allows you to get your product to market a little sooner, a little cheaper, a little more reliably. In consequence, we simply are losing market share, and we have been losing it in industry after industry.

So, although we may not want to really get involved in what is normally called an industrial policy, we have a very important role in changing some of the culture in this country back to the firm belief, for example, that manufacturing does matter. I believe, and I have stated many times, that we are victims of a myth in this country, a myth that says that we have moved in a somewhat graceful fashion from an agricultural to a manufacturing to a service economy, dispensing with the ones that have gone by as we moved into the new arena. I submit to you, sir, that that is total nonsense. You cannot have a vibrant service economy unless you have a strong manufacturing economy underlying it, just as you do not have the strong manufacturing economy without a strong agricultural one.

We have to take a new look at where this myth has led us. It has led us in high technology, for example, in directions which simply have not served us at all well in an international marketplace. So we have a role, a very important role, from the discovery to the production phase. We should be in there helping companies to get together, to cooperate, to develop the technologies that all will subsequently use in whatever way they find best, and then compete.

And we have a real role in trying to change the culture, the educational background, that will make us more effective producers.

Senator GORE. Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Dr. Bromley. I, like Senator Gore, have an enormous amount of admiration for you, and you know that, but I must say I am struck in your comments and by the part of the hearing which I have heard, by a kind of a wandering sense. You talk about our lead in basic research. Well, in everything we have had a lead. The Japanese are now getting heavily into basic research, and you know that. You did not say that, but you know it.

The Administration is not smart enough to pick winners and losers. Administrations have been picking winners and losers for years in agriculture and nuclear technology, biomedical, pharmaceuticals, clean coal research—you can just go up and down the list. I mean, you talk about myths. That is one myth that ought to be laid quickly aside, and particularly by scientists of your distinction.

I want to hear you say it. The Commission Report was strong stuff. It said that we are in a decline in semiconductors. We are in a decline. It is my general understanding that if the semiconductor industry is in decline, then the electronic industries underneath it which lead to its refurbishment have to be in decline also, and of course that is one of our earlier histories. That was one of the earlier productions to get away from us. The thing says we have got to act now. There is really strong language, it seems to me.

I would just like to know if you think, for example, that the semiconductor industry is in crisis, that it is deeply troubled, that there is a severe crisis there, that the Nation should act now, and as the report says, that the Government needs to be involved in that at every level, as it says, the report. Do you agree with that, or do you think that semiconductors are like a lot of other troubled manufacturing sectors and deserve that kind of attention?

Dr. BROMLEY. I would not call it a crisis, Senator.

Senator ROCKEFELLER. Why would you not?

Dr. BROMLEY. Because there is great strength in this industry still, and I have every confidence that by working with the industry this Administration can, in fact, reestablish a much stronger industry than we have even at this moment. For that reason I do not call it a crisis.

I do have—I agree with you that the Committee has documented a very serious situation, a serious decline in a very critical enabling area of technology that underlies a great fraction of what we do. There is no question about that. The Committee has made a whole series of recommendations, and as I have testified previously the Administration in fact is in agreement with a very large fraction of those recommendations. The one that I focused on, the Consumer Electronics Capital Corporation, is the one where there is really a difference of opinion, and that is really the only one where there is a substantial difference of opinion.

What we are doing—what we are trying to do is work with the industry to explore with them how Government support could most effectively be utilized.

Senator ROCKEFELLER. How much time do we have to make those decisions?

Dr. BROMLEY. I hope, for example, that we will hear back from our industrial colleagues within matters of weeks. That is the time scale we are talking about. We have asked for specific analyses on their part as to how would the following changes affect your industry. We would like to see those results before arriving at specific policies.

Senator ROCKEFELLER. But you have already cast out one specific policy. You have said that we are not smart enough to pick winners and losers.

Dr. BROMLEY. In the production level we specifically do not—this Administration—let me put it that way. This Administration I do not believe will ever support the Consumer Electronics Capital Corporation.

Senator ROCKEFELLER. Do you believe this Administration is right in coming to that policy?

Dr. BROMLEY. I am a member of this Administration——

Senator ROCKEFELLER. I understand that.

Dr. BROMLEY. And I am here speaking for the Administration, and therefore I am presenting that position.

Senator ROCKEFELLER. Now, you say that we are not smart enough to pick winners and losers, while at the same time you admit that we do as a matter of regular course. You understand perfectly well that airlines, shuttles and all kinds of things—you understand what the Japanese are doing. You understand what the Germans are doing——

Dr. BROMLEY. Yes.

Senator ROCKEFELLER. And you express concern. I agree with Senator Gore. The President—it is just like they are sitting up there at that White House waiting for each other to say something about the budget, and the Japanese can play with us like they have in the past.

Last week at one point the stock market was way down, and the Japanese came in three minutes before the close of the market and bought our Treasury bonds that we have to sell on a quarterly basis and the market went back up. That is playing with us. I think they were waiting for the 8.8 rate that they got.

But the point is, we are in crisis here. You know that perfectly well, and we are wondering. You are not suggesting anything specific. You have much stronger instincts inside yourself. You are chafing at your job. You are speaking for the Administration. It seems to me that we all understand what is happening. You do not have to put it in industrial policy terms if you do not wish, but it seems to me at some point that one—that you either get some of these people at the White House to go along with what you know needs to be done, Dr. Bromley, which you probably better than any person in this country know needs to be done, or get out of their and make the point by that reason.

I think we are in severe crisis, and I think it is terrible for a man of your distinction, who I so totally admire, to sit up here and to toe the Administration line, because of course you have to, I do understand that. But I think you ought to give yourself a period of time, pound away as Senator Gore says you have been doing, and if

they do not respond then get the hell out of there and go back to Yale and teach some other people who can do it right.

Now I have a question for Mr. Armstrong—and I apologize to you, Dr. Bromley, but I am frustrated by that answer, and I think you know that I say that lovingly.

A quick question for Mr. Armstrong, because I think IBM has no special merit badges to be worn. What is it that you bought back in stocks, 10 billion buy-backs?

Dr. ARMSTRONG. I am not sure whether it is 10 billion, but it was a substantial amount of money.

Senator ROCKEFELLER. I am talking about stock purchases. Now, critics would like to see the private sector get going, and it has been quite remarkable, the course that IBM has followed up and down in recent years. Obviously, it is a giant, on the leading edge and all the rest of it, but you have been through some rather turbulent times, as they say.

Why is it that you have to buy back stock so that you can get a better deal for your stockholders instead of spending more time on lap-top computers or supercomputers? How can you defend that corporately? Why is that not simply short-term thinking to maximize profits so that you get yourself in a better position in the stock market as opposed to precisely the kind of ducking that I think that Dr. Bromley is unwillingly but necessarily having to do? You are the private sector. I do not have to be polite to you.

Why the hell do you do that stuff, when that money could much better go back into the company to make yourself more aggressive?

Dr. ARMSTRONG. Well, senator, first of all I should say that my expertise, such as it is, is in research and development and not in finance, so I am the wrong person to ask that question, as far as the use of cash.

Senator ROCKEFELLER. Well could you find the right person and send the Committee an answer?

Dr. ARMSTRONG. Yes, I can get you a comment on that.

I would like also to point out that the IBM Corporation, since you asked me about that, not in my role as a member of NACS, but the IBM Corporation invested $6 billion in research and development last year and will invest more than $6 billion in R&D this year, and we have invested over the last ten years probably $50 billion in research and development.

Senator ROCKEFELLER. Right.

Dr. ARMSTRONG. So I really believe, Senator—I am not an economist and I am not a financial analyst, but the uses of cash in a corporation and the investment of retained earnings in research and development are different transactions. We are investing very substantially in research and development, and as you know, and as will come up later, we have for years almost single-handedly carried the investment, for example, in X-ray lithography in this country.

Senator ROCKEFELLER. My time is over and I have to leave, but if I could just say one thing, I think the $6 billion is great. I think the $10 billion is a bigger number and a worse trend.

Dr. ARMSTRONG. But, Senator, those two numbers with all due respect are not fungible.

Senator ROCKEFELLER. Well, they may not be, but they are impressive to me, and it just seems to me that one drives for the long-term, and I think IBM, if any company, ought to be looking at that in a new way. IBM ought to be that company.

A UCLA professor—Senator Gore, forgive me for this last thing—says, "When industry passes into the hands of people who are more interested in money than in innovation, it loses something important." I mean, I could have quoted myself or any of you or any thinking American on that subject.

In Japan and other countries, people that have engineering and mathematical and scientific backgrounds get to become CEOs. In America, they are marketing specialists accountants or lawyers, and I would ask Dr. Bromley if he does not think that is rather a substantial behavior modification problem that this country needs to face.

Dr. BROMLEY. It sure is.

Dr. ARMSTRONG. Senator, I really would like to say one further thing. I believe it is a fair reply for me to tell you that the IBM Corporation invested in R&D over the last few years the amount of money that it thought was required for our business.

Senator ROCKEFELLER. Well, number one I do not believe that, and number two, I would like to have an answer for the Committee as to why the $10 billion buy-back was considered so important and if it was done for some reason, some substantial reason other than lifting the position in the market.

Thank you, Mr. Chairman.

Senator GORE. We will hold the record open for that response.

[The following information was subsequently received for the record:]

Our share repurchase program has had no effect on our research and development activities or plans. Moreover, the amounts we have invested have been sufficient to provide us with the technologies and products needed to participate in the growth opportunities of our industry.

Our share repurchase program began in 1986. Through 1989, we spent about $5.7 billion, or an average of $1.5 billion annually. During that same period, IBM's R,D&E expenditures exceeded $23 billion (increasing each year), and we maintained an average cash balance of over $4 billion available for additional investments such as R&D should that have proved necessary. In 1989, our R,D&E spending was $6.8 billion, or 11 percent of our sales.

Moreover, we are firmly committed to improving the infrastructure of the electronics industry. Some examples include. IBM's 1983 temporary investment in 15 percent of Intel's equity; sharing our billion dollar X-ray lithography center in East Fishkill, NY, with others in industry and with the U.S. government; providing IBM's 4 megabit DRAM technology to SEMATECH, and licensing it to others such as Micron Technologies; and our involvement in the recent restructuring of Perkin-Elmer, a vitally important American toolmaker.

Where the situation warrants, IBM is prepared to participate in further thoughtful efforts to ensure that our country remains competitive in high technology electronics.

Senator GORE. I have a few more questions for you, Dr. Bromley, and we will get you out of here by 10:45 a.m.

I thought I heard you say a moment ago that the recommendation for creating this Consumer Electronics Capital Corporation was the only recommendation by the panel with which the Administration disagreed.

Dr. BROMLEY. It is the one with which we have the major disagreement.

Senator GORE. Let me ask you about some of the others, then. They recommend that the Department of Energy should ensure the transfer of synchrotron x-ray technology and systems for microlithography by having two corporations design and build prototype rings, and by funding the participation of national laboratory experts in these projects in order to assure timely availability and rapid insertion of these critical technologies. DARPA, DOE and the Department of Commerce programs in mask making, mask repair, aligners, metrology and small x-ray sources must be pursued aggressively, as well.

Do you agree with that recommendation?

Dr. BROMLEY. I think that is a good recommendation, and DARPA and DOE are looking into that.

Senator GORE. Is the Administration going to do it?

Dr. BROMLEY. Well, it is too early to say. DOE and DARPA are looking into this recommendation at the moment.

Senator GORE. Is it likely the Administration will have two corporations design and build prototype rings and then fund participation by the national labs in these projects?

Dr. BROMLEY. Mr. Chairman, I cannot say in detail. I can simply tell you that this whole question is one that is recognized as being of national importance. The National Light Source at Brookhaven, the new program that is underway at Argonne, the program at Berkeley and at Wisconsin, are all being directed, and the people that are most expert in these areas are now addressing these questions. We do not have an answer for you yet, but we will have it.

Senator GORE. Okay. This recommendation came out six months ago. How much longer will it take before the Administration is prepared to say whether or not it agrees with it and will pursue it?

Dr. BROMLEY. I would fully expect that in our 1992 budget submission to you that we will have a section that will——

Senator GORE. The 1992 budget submission?

Dr. BROMLEY. In the next budget submission.

Senator GORE. A year from now we will get an answer on this?

Dr. BROMLEY. A year from now you will get some concrete plan.

Senator GORE. Do you think that is good enough?

Dr. BROMLEY. Perhaps I should say I do not think it is going to happen before that.

Senator GORE. You get away with an awful lot by style, you know, you really do.

I just hope the Administration understands what you are saying as clearly as I think we do. No, it is not good enough. Obviously it is not good enough.

Here is another recommendation. SEMATECH's funding should be increased immediately by $100 million, half of which would be provided by developers of such equipment, materials and processes. This is in addition to funding a shortfall of $800 million that exists over the next three years for programs to fully address the needs of this industry segment.

Do you agree with that?

Dr. BROMLEY. I think it is an excellent recommendation; it is simply a question of availability of funding.

Senator GORE. Will the Administration do it?

Dr. BROMLEY. If we have the funding, it is something that many of us in the Administration would very much like to do.

Senator GORE. Well, again, it is the same story. You know what the right thing to do is. I feel confident that you are giving the right advice. And you are impressively loyal to the Administration in crafting responses in a very delicate and diplomatic way, but the President is not doing anything. He is not responding. And he is letting this critical industry slip away from America's future.

Another one of their recommendations is to build the national fiber optic network, the information superhighway network. You agree that is a top priority, do you not, Dr. Armstrong?

Dr. ARMSTRONG. I do indeed, Senator.

Senator GORE. Okay. Now we have had a response from the Administration on that—the same old story. Dr. Bromley, you know why that is important. You are giving the right advice, I am sure. Here is what "Communications Week" said in a lead editorial recently. And I want to quote three paragraphs here:

> Critics of President Bush and his Administration commonly make two complaints, they say Bush fails to lead in situations that cry out for leadership. And they say his Administration will not put up any money even when Bush does take a stand. When it comes to the proposed National Research and Education Network, Bush and the Administration look guilty on both accounts. Bush certainly is providing no leadership here.
>
> The proposal for the network came in a bill submitted to the Senate by Albert Gore, a Democrat from Tennessee. Had Bush cared to stake out a position, he could have thrown his weight behind the bill. Bipartisan support almost certainly would have ensured its passage. Instead, the Administration let it be known that it was in favor of the network, but that support came from Bush's Science Advisor, Allan Bromley, and the Office of Science and Technology Policy, of which Bromley is the Director. Bush himself was not heard from.
>
> And it now appears the Administration support is something less than wholehearted. It is in favor of a high-speed national research network, but it is opposed to Gore's bill. In other words, the Administration seems once again to be taking a position, but refusing to do anything that might actually advance that position. In shorter words, it will not put any money where its mouth is.

Senator GORE. But it is this same story. It is the same thing we have heard about x-ray lithography, about SEMATECH, about every single recommendation this Advisory Committee directed towards saving, rebuilding and regenerating the vital semiconductor industry in the United States. It the same story.

The Administration says nice things, that is, the President, through you, Dr. Bromley, but the President himself says nothing. The President does even less. And even where a position is defined by the Administration, there is zero money and zero effort.

Again, let me say, because I respect you so much, do not misunderstand, I admire the job you personally are doing, and part of your job is to listen to this.

Okay.

You are doing your job great right now, Allan.

And to listen to it from the industry as well, and then to take it back to the President and say—I want you to go back to the White House and say, Mr. President, the hounds are getting closer.

They are on to your game. They have figured out that you are faking on this policy. They have figured out that it is a game of shadow puppetry, with images and no substance, with words and

no money. And Mr. President, I do not know how much longer I can put up this front.

You do not necessarily have to say that.

I hope you will have tremendous success in this incredibly difficult mission you have.

But really it cannot go on. What the President is doing cannot continue for much longer, or else the results predicted in this report are almost certainly going to come to pass.

Let me give you a chance to respond, and then we will get you on out of here.

Dr. BROMLEY. To the last point, Mr. Chairman, as you well know, I support you entirely in that one of the most important things we can do for this Nation is to put together a broad band network system. I have, I think, made some very concrete steps in that direction.

I got into the system too late in this last budget cycle, but I have now a formal agreement with OMB that we will in fact do the crosscut and we will develop an integrated program for the Nation involving all of our agencies. And also we are drawing on a very distinguished private sector panel that we promised we would put together, and that with your help we have put together. And by our next budget cycle we will be making very concrete moves.

I would also say that I have now gotten commitments from some agencies to begin some reprogramming already, to begin to move in this direction of high performance computing and networking, because I share your feeling that this is a critical area for the United States. It is one where we have a window of opportunity that we will miss if we do not act. And we have a goal in my office, which is being now developed by the Federal Coordinating Council, to double the investment in this area over the next few years.

And with your help we can make this happen.

Senator GORE. May I interject just one brief point there, again, from this "Communications Week" editorial. "When it sent the 1991 budget to Congress, though," and I am quoting, "the increase turned out to be only $21 million for the network."

Dr. BROMLEY. Five percent.

Senator GORE. "Gore's bill, by contrast, would allocate $1.9 billion over five years. That works out to $380 million. The difference should be noticeable even to government accountants."

Go ahead. I am sorry to interrupt.

Dr. BROMLEY. That is all right. I simply plead that I am not a government accountant.

Senator GORE. Okay.

Did you want to respond to any of the rest of it?

Dr. BROMLEY. I think you have made your point very clearly, Senator.

Senator GORE. All right.

Dr. BROMLEY. Thank you very much.

Senator GORE. We appreciate your presence here very much, Dr. Bromley. And keep up the good work, and we hope you have more success with the President.

Thank you for coming.

Dr. BROMLEY. Thank you. With your permission, sir, I must leave.

Senator GORE. Indeed, with our permission and respect.

Dr. BROMLEY. Thank you.

Senator GORE. We are now going to pick up where we interrupted the flow of the hearing to accommodate Dr. Bromley. And our next witness is Mr. Joe Parkinson, Chairman of Micron Technology.

Mr. Parkinson, please present a summary of your statement, if you would.

STATEMENT OF JOE PARKINSON, CHAIRMAN AND CEO, MICRON TECHNOLOGY, INC.

Mr. PARKINSON. Thank you, Mr. Chairman. After hearing these speakers, I hope I am not singing to the choir. I think we are all pretty much on the same wavelength, but I do want to thank you and the Subcommittee for giving me the opportunity to appear before you today.

Micron is a semiconductor manufacturer located in Boise, Idaho, and I guess we are here today because we have been in probably the prime targeted industry that the Japanese had focused on, namely DRAMs, as their method of eventually dominating the entire computer industry, and when you refer to the Japanese going from 0 to 75 or 85 percent market share, I would like to point out that the United States still does have a remnant of this industry and that Micron is still in that industry.

We, as well as IBM—our friends from IBM—are fighting back, that just because the Japanese are in this industry is no reason to feel dumber than a post by staying in it. That is the way most of the industry has felt, I think, over the last ten years.

But for those who do stay and do have this long-term focus that you alluded to, there are certain spoils that go to the victor. Last year, we had $446 million in sales and $105 million in profits, and we are continuing to expand in the high volume end of the industry as opposed to the niche end of it.

We have branched out from DRAMs, which is the largest segment of the $10 billion market, and are now into the second largest, which would be static RAMS, and I think this month have just introduced the highest speed 1 meg static RAM on the market, and we are also making VRAMs which would be the third largest segment of the memory market, so the industry is still alive in the United States and we are not in it to survive, we are in it to prevail against the Japanese, and I think that between IBM and Micron we will do that.

Our company succeeded in DRAMs when so many others failed because we had no other choice. We felt that you are either in DRAMs, in the high volume segment of it, or eventually you will be out of it, because there are only so many holes you can hide in and eventually I think you have to turn and fight these guys, and that is what we are doing.

We have delivered the highest quality product. When the Japanese have a perceived quality advantage you cannot be just as good on quality, you have to be better, and we have innovated what is known as intelligent burn-in, whereby we not only burn in the product but test it while on burn-in, which has increased our test

times from about 30 to 45 seconds to 24 hours, and by doing so we won the highest quality award that NCR has ever handed out, and we just received another quality award from Northern Telecom and I think we are being perceived as the highest quality producer on the market, and I think it is possible to beat the Japanese in every arena.

The other reason we survived is we made a DRAM half the size of the Japanese which went on a five-inch wafer. We shipped 1,000 units, and their maximum output was 400 units, and that gave us a cost of production which was far better than the Japanese. Even though we had half the cost, the Japanese were selling under our cost, so we were the ones that instituted the anti-dumping action and we eventually prevailed against all of the Japanese manufacturers. Unfortunately, by the time those actions were concluded and the SEMATECH agreement was reached, 55,000 jobs had been lost to the United States and somewhere around, by my calculation, $4 to $5 billion in investment had been written off.

I can say to you that it is a lot easier to shut down these fabrication facilities than it is to restart them, and I hope that your Committee will focus on that issue as well. Just as there is agony over choosing winners and losers, it seems to me if we could have quick action when one of these industries is under attack, that that will be far more effective in at least preserving a remnant of the industry to come back than it will be to starting from scratch.

Now, the long-term effects of the United States losing these markets is evident to the Committee and I do not think I am going to dwell on that, but I did want to add a couple of other points and reinforce the position that when you lose the high-volume side of it there are other domino effects, and we have seen it, for example, in the raw wafer side of it. Just the last U.S. producer was sold to Huls AG just recently, and we are already seeing shortages in this critical component, and this is a favorite Japanese technique, is not only undercut you from a price standpoint but also from a supply standpoint.

To give you another example, we are being bombarded by recruitment advertisements and head-hunters in our facilities right now, as the Japanese try to hire away our remaining key engineers and key people, so they come at you from every angle, and I think we need to recognize that that is happening. Also Materials Research Corporation, the last major United States supplier of sputtering targets, is being sold to Sony, and I think that is going to be another tragedy in terms of infrastructure and supply to the remnants of the high volume industry.

I see a lot of press recently that has been disappointing to me in terms of the efforts in negotiating with the Japanese, and I can only say to this Committee that just as you have perceived that we—or other members of the Committee have perceived that we are dependent on the Japanese for financing our bonds—I think it was Senator Rockefeller's comment—and we are reluctant to bite the hand that appears to be feeding us, I am seeing that in the computer industry, too. A sense that the Japanese are supplying 80 percent of the DRAMs, which are such a critical component of the computer industry that the computer customers—the American computer customers—are fearing to bite the hand that feeds them,

and that is why I think Japan was not named as a Super 301, and it is not only on the financial side, but I would say on the DRAM side of it, that we need to be sensitive to that.

I just think that this Committee and this Administration needs to face up to the fact that we have got to fight back against these people. You have got to give encouragement to the remaining manufacturing segments of the United States that these markets will be protected. You are going to hear a lot about weakening—they never call it weakening the antidumping laws, but I can tell you that any talk of amending it needs to be carefully evaluated, because right now selling below cost is prohibited, and it may be slow to win an antidumping action, but I can tell you we won one and it was effective, and it has preserved what are now 3,500 jobs in Boise, Idaho.

But if the advocates of the Japanese position, and that is what I would call them, are allowed to prevail, we are going to have what is called forward pricing, or average pricing over the life of a product, and that will destroy, in my opinion, the remaining remnants of the DRAM and other industries that are competing with the Japanese, and I would just say that these people have become addicted to cheap, foreign DRAMs and that they will eventually pay a price if they pursue that line, and we need to vigorously and quickly enforce those antidumping laws, and that will then encourage a revival of manufacture and production of these high volume items in the United States.

One final point, and I have been back and testified to several committees over and over, and I have been saying this for many, many years, and I am going to say it one more time, that when we sell to South Korea we pay a tariff so high I cannot even tell you what it is, but it is somewhere 20 to 40 percent. I am not sure what it is, for DRAMs. When Samsung ships to the United States, the tariff is zero. When I ship to Europe the tariff is 14 percent across the board. When Siemens ships to the United States, the tariff is zero.

I have never been able to sell into Japan and neither can any of these other foreign suppliers, and that means any excess capacity is going to come to the United States, and that creates a further deterrent to reinvestment in these high volume markets, because this is the only open market and the only market where they dump without restraint. That is a serious on-going issue, and I just cannot see why we cannot quickly—you are impatient, I am impatient—finally end these tariffs in South Korea and Europe so that we have other outlets for our markets.

Thank you very much for your patience, and again it is a pleasure to be here with such able panelists today.

[The statement follows:]

STATEMENT OF JOE PARKINSON, CHAIRMAN AND CEO OF MICRON TECHNOLOGY, INC. BEFORE THE SENATE SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE.

Good Morning. Thank you, Mr. Chairman. My name is Joe Parkinson. I am chairman and chief executive officer of Micron Technology, Inc. I would like to thank you, Mr. Chairman, and the Subcommittee, for giving me the opportunity to appear before you today.

Micron Technology, Inc. is a semiconductor manufacturer located in Boise, Idaho. Originally founded as a consulting company in 1978, the company began manufacture of semiconductors in 1981. From our Boise location the company designs, manufactures and markets semiconductor products including dynamic random access memory components (DRAMs), one of the most widely used semiconductor components in computer systems. We also make static random access memory (SRAMs), video random access memory (VRAMs), and a variety of module and board level products. The plant in Boise includes design, wafer fabrication, test, and assembly facilities, making our company the only American owned company manufacturing DRAMs which has its entire production process onshore. We currently employ approximately 3,500 people. Micron is a merchant manufacturer, which means we sell our products in the open market rather than producing them for our own use. Sales last year were $446 million and profits were $105 million.

Our company succeeded in DRAMs when so many others failed because DRAMs were our primary business and we had no choice.

Our employees pulled together as a team and succeeded in developing a product with the fewest mask steps and smallest die size, thus the lowest cost, in the industry. Our high quality product has resulted in long-term relationships with most of our customers.

We have succeeded in spite of obstacles. We faced tariffs on our products overseas (14% tariff into the ECC countries and 20% into South Korea) but foreign producers paid no tariffs for their products coming into America. Japan maintained closed markets to foreign semiconductors, but American markets were open to all. Japan targeted for development semiconductors and the information industry, helping companies with low cost capital, joint research, and government assistance.

The result--foreign manufacturers were able to substantially increase production capacity which caused prices to plummet. In 1985-1986 alone prices dropped over 80% in one year. United States companies were forced to leave the industry. In 1984 the United States had at least eleven companies making DRAMs and the industry leaders were Mostek, Texas Instruments, Motorola, Intel and National Semiconductor. By 1987 the United States had only two DRAM companies left and the leaders were NEC, Hitachi, Toshiba and Fujitsu. The United States' share of the worldwide DRAM market fell from over 60% in 1980 to less than 15% in 1989. Japanese market share rose from less than 40% to over 75% during the same time frame.

Long range effects of this situation are still being felt. Japanese customers still buy from Japanese manufacturers,

purchasing American goods and equipment only when Japanese product is not available or until the product can be made in Japan. Fewer American semiconductor companies in the United States has resulted in lower demand for equipment and supplies made in the United States. In April 1989 Monsanto, the last major United States supplier of silicon wafers, was acquired by Huls AG. We now face shortages of this critical raw material. Materials Research Corporation (MRC), the last major United States supplier of sputtering targets used in the production of 4 Megabit DRAMs, announced in August 1989 that it would be acquired by Sony.

As many of you know, the Department of Commerce found in 1986 that the Japanese semiconductor producers were dumping DRAMs into the U.S. market. As a result of these findings, the U.S. concluded the Japan-U.S. Semiconductor Agreement, in return for which the U.S. industry agreed to the suspension of the DRAM investigation. The Agreement has helped to prevent dumping over the past few years. The Semiconductor Agreement was also supposed to improve U.S. semiconductor producer's access to the Japanese market. Although the numbers have improved somewhat since the Agreement was signed, market access has nowhere near approached the 20 percent level which is the target of the agreement. Micron is trying to do its part and has established an agreement with a Japanese marketing representative. Our negotiators need to continue their efforts, however, to press for the elimination of barriers in Japan which hinder our access to their market.

We still face problems which make fair competition improbable in our industry. We are paying tariffs when our goods are shipped to most other countries; they pay none when their products are shipped into the United States. Cost of capital is inequitable between competitive countries, exports are restricted or delayed because of red tape and licenses, and our educational system is not providing employees with the skills necessary for high technology knowledge and quality intensive industries.

We are pleased that this Committee recognizes the seriousness of this situation. The recommendations of the National Advisory Committee on Semiconductors are an excellent beginning and provide some positive suggestions for action and progress. In my view the most important things we need to address are trade practices, tax policy, education programs and the deficit.

1. Trade Practices. Trade policies need to be revised and a proactive stance taken to trade regulations and situations. Policies need to be set to eliminate tariffs, broaden exports and prevent dumping. It seems self-evident that as long as other countries are allowed to impose tariffs on our products when we don't burden theirs, we can never have free and fair trade.

The February revisions on integrated circuit export regulations made great improvements, but board level and other semiconductor product export restrictions need to be reviewed and revised in order to remove or simplify administrative burdens on exports. Export licenses are currently required for board-level product shipments throughout the world, even on our oldest

generations of products. It is tough enough competing when foreign governments support their industries. It is even harder when our own government places administrative burdens on our exports. And, of course, we are restricted from selling most of our major products into Eastern Block countries. However, when Toshiba sold machine tools to Russia and seriously jeopardized our defense efforts they virtually received no more than a slap on the wrist.

United States antidumping laws must be vigorously enforced. The FMV calculations in the antidumping law and the Japan-United States Semiconductor Agreement should not be changed. Also, we should continue our tough negotiating for a strengthened antidumping code in the GATT. In no instance should we even consider "forward pricing", price averaging, or any other scheme which will allow foreign producers to sell their product in the United States at less than actual cost.

2. **Tax Policy.** Maintaining or improving the United States position in semiconductors requires substantial investment in continual research and development. However, year to year extension of the R&D tax credit makes long-term planning for research and development expenditures difficult. We suggest that the credit be made permanent. In addition, the credit should be expanded to cover not just labor and supplies, but individual items of equipment used in research and development as well. We agree with the recommendations of the National Advisory Committee

on Semiconductors which states the size of the credit should be increased and be made applicable to all, not just incremental, R&D.

Depreciation schedules for the semiconductor industry should be modified to reflect the rapid technological obsolescence of semiconductor equipment and facilities. Our equipment is obsolete in less than the traditional five years and, in most instances, has to be replaced in two or three years at the most. In addition, buildings and facilities should be allowed an accelerated depreciation schedule. In today's industry a fabrication facility costing $300 million will have a useful life of less than ten years, even if all of the equipment is replaced and the facility totally renovated. Let me suggest that a taxpayer election allowing even a one hundred percent write-off in the year of construction of a new facility would not be inappropriate in order to stimulate investment in the industry.

3. **Education Programs.** We must strengthen our educational system. Schools should again place major emphasis on the basic core courses--English, writing and communication, math, science and work ethic. We agree that throwing money at the problem is not the only answer. EVERYONE has to be responsible for the educational system from parents and students, to principals and teachers, to superintendents and school boards, to local businessmen and legislators, to congressmen and senators. We must let educators know what business needs from students, and what skills and information are valuable. Citizens must be willing to volunteer time in the schools to give students a look

at what is necessary and possible in the "real" world. Parents need to spend time working with their children, and students need to work hard at their job of learning. We all need to realize education is important and necessary for our future.

As in industry and all of America, quality must be required. We all, as taxpayers and citizens, need to receive the best possible value for our money, time and efforts. Education is no exception.

4. **The Deficit.** Finally, we absolutely must reduce the national debt and foreign trade deficits. 1969 was the last year we had a federal budget surplus. Today the national debt stands at over $3 trillion dollars. The money we are paying to finance this debt could be used by individual companies for research and development, and by the nation for incentives and growth of our national infrastructure. The $100 billion trade deficits are equally intolerable, and the cumulative impact is staggering and demoralizing. We used to pass on assets to our children, but now we will pass on an overwhelming debt and they will not have the productive capacity to repair it.

Again, I would like to thank the committee for allowing me to appear today. I have pointed out a few items I feel are of major importance. I ask you to consider my comments and would be willing to help the Subcommittee in any way I can. Unlike some of your witnesses, Micron does all its production in Idaho, and none abroad, so our interests are strictly in the United States.

Senator GORE. Thank you very much. Dr. Lubin, we will hear from you next, if you could summarize your statement for us.

STATEMENT OF DR. MOSHE J. LUBIN, PRESIDENT AND CEO, HAMPSHIRE INSTRUMENTS, INC.

Dr. LUBIN. Mr. Chairman, thank you. My name is Moshe Lubin and I am co-founder and President of Hampshire Instruments. We make printing presses. We are part of that tool set for the semiconductor capital equipment industry. Parenthetically, my company is a member of SEMI, or Semi-Equipment Materials International, and while I am not testifying today on SEMI's behalf, with the Committee's permission I would like to submit for the record the testimony for SEMI by Edward Braun from the SEMI organization.

Senator GORE. We will hold the record open for that.

Dr. LUBIN. Hampshire Instruments was established in 1984 to engage in the design and development and manufacture of the first laser-based X-ray lithography Stepper for the production of state-of-the-art and advanced integrated circuits. It makes use of a unique American technology, the result of investment that has been made in American technology since the mid-1960s and earlier.

We happen to be a small developing company but still of the opinion that robust and even leadership positions in manufacturing is still the realm and possibility in the United States, and today rather than focus on the NACS report's recommendations, with which we agree wholeheartedly, if in one or two cases with some reservation, I would like to make comments on the cost of capital and bridging the transition between innovation and introduction into efficient production, which in fact does produce the economic advantage that allows this country to go on.

I will use lithography or the printing presses as an example, because it is a pivotal manufacturing modality for integrated circuits. The present lithography systems that are used worldwide to manufacture integrated circuits were also an American invention. In fact, it was not too long ago when the United States manufacturers of this equipment had 90 percent worldwide market share. To date, it is less than 15 and shrinking.

The pioneering companies that were involved in the establishment of these printing presses are in very difficult shape and in some cases have disappeared from the scene. The decisions that the U.S. Government and the U.S. semiconductor industry make today to commit resources for the production of advanced chips for world markets will in fact, as everybody agrees, have a powerful effect on the country's competitive and economic position.

The cost of developing and bringing to market a qualified lithography tool or printing press is between $75 to $250 million. In order to play in this game, a U.S. firm must have access to that kind of money at competitive rates, and then it must have the financial resources to commercialize the tool by having it tested to make it suitable for efficient semiconductor production. This clearly is not for the faint at heart.

For example, in the seven years since our company was founded we have invested approximately $60 million in product development. Approximately one third of that has come from equity inves-

tors. Even these far-sighted investors must play in the capital environment that has dominated our Nation and stifled, to some extent, the commercialization of innovation in its lead to economic advantage.

Hampshire is particularly proud of the support it has received from New York State to help foster the industry, and has also benefited from the forward-looking elements in the national X-ray lithography program. DARPA, as one of the Government's constructs, has also done an excellent job in managing the X-ray lithography initiative, but it is far too small to have an impact.

Our Federal appropriations commitment to this technology does not and cannot compete with the hundreds of millions of dollars that our Pacific trading partners are spending in advanced tool sets, but the main point here is that it may not be necessary for us to compete dollar for dollar. We can, in fact, be smarter. At the beginning, I stated that a critical barrier to regaining our leadership in semiconductor equipment was the high cost of capital, and that we need to utilize present mechanisms already in place as opposed to a new industrial policy to focus lower cost capital on comprehensive test-bed programs for the American semiconductor capital tool industry.

The U.S. Government needs to recognize the importance of this industry and this technology, and needs to realize that the tool set for capital goods required for us to be competitive will not be available without access to low-cost capital, and second a test-bed program supported by adding new funds and dedicating those funds to burning in those new tools. If we are to regain technological leadership in semiconductors, a test-bed program for new generations of the tool set can be an effective element in that implementation.

The good news is that once the test-bed phase has been achieved, private industry is more than capable of carrying the ball. America's preeminence in world agriculture would never have been achieved without the homesteading program, land grant colleges, rural electrification and Government-supported agricultural research. We would not have achieved supersonic flight or commercial jet aviation without the Government's support of facilities, prototypes and equipment devoted to Chuck Yeager and his colleague test pilots.

Applying the same principles, we must provide affordable capital and Government support to testing critical new generations of capital equipment. I am proposing today a three-way partnership between semiconductor companies, the leading edge capital equipment producers and the Federal Government.

The test-bed host semiconductor manufacturers would support the cost of integrating test-bed capital equipment in their pilot line fabrication areas. Capital equipment makers would support the diagnostic engineering and engineering upgrades, reliability and quality testing, installation, operation, and would of course manufacture the test-bed machines, and the Government would furnish and purchase these machines to test-bed host companies as Government-furnished equipment.

The program I propose, Tomorrow's Equipment for Semiconductors Today, or TEST, would significantly accelerate the insertion and qualification of equipment needed to regain semiconductor

manufacturing leadership. In the case of Hampshire, such a program would ensure that the technology transfers and joint efforts we are engaged in now with the National Labs could quickly take wing.

We believe that the concept of a national semiconductor test-bed initiative is an opportunity for the Government within the present structure to support what the Administration has called precompetitive research and development that can add value to our Nation and restore leadership to a critical support beam in the very foundation of the American industrial base.

[The statement follows:]

STATEMENT OF DR. MOSHE LUBIN, PRESIDENT AND CEO, HAMPSHIRE INSTRUMENTS, INC.

Mr. Chairman, my name is Moshe Lubin. I am a co-founder and President of Hampshire Instruments, Inc. Hampshire was established in 1984 to engage in the design, development, and manufacture of the world's first laser-based X-ray stepper for the commercial production of state-of-the-art integrated circuits.

NACS REPORT

The creation by Congress of the National Advisory Committee on Semiconductors can, in my opinion, be viewed as a pivotal action in the continued economic success of the United States.

It is my view that restoring America to a competitive or leadership position in semiconductor equipment will require steps to make competitive capital costs available to our industry using existing mechanisms and programs. There is simply not time for more studies, or to create new institutions or bureaucracies to address this critical problem. We must use the mechanisms already in place and make them work better by targeting them specifically at the goal of restoring competitiveness in this critical field. The best, and most efficient way to deliver this goal is to make capital available for a comprehensive test bed program for advanced semiconductor equipment. While the concept of a test bed program does not appear in the NACS report, I shall elaborate on these thoughts following my comments on the NACS report's recommendations.

To avoid relegating the NACS report to gathering dust on the shelves of policy makers, we must now move forward on its keystone recommendations:

1. The United States must promote competitive costs of capital, so that the smaller entrepreneurial U.S. equipment makers can stay afloat and continue to develop world class tools to compete with or outperform our foreign rivals.

2. We must improve our K through 12 education system to provide a constant flow of highly qualified science and math teachers and engineering professors.

3. We must reform trade laws to provide the level playing field discussed by so many.

4. We must protect the intellectual property of U.S. citizens and U.S. companies.

5. I support the proposed legislation to modify the national Cooperative Research Act, which has been extremely successful, to include manufacturing joint ventures.

6. I strongly support the NACS recommendations to expand the U.S. technological base, including:

-- The funding increase proposed by the NACS report for SEMATECH -- an immediate increase of $100 million -- while very conservative, will result in a great boost to our competitiveness posture.

-- I also strongly support the NACS recommendations for:

- Continued funding for silicon R&D.
- Increased funding for academic research and teacher development.
- Changed immigration laws to allow foreign-born graduates from U.S. universities to obtain permanent residency permits within three months of graduation.
- Doubling the number of federally funded fellowships for natural science and engineering and increasing the real monetary value of the awards.

NACS Recommendations on X-ray Lithography

Mr. Chairman, I have saved another NACS recommendation until last. Hampshire is in the forefront of the development of X-ray lithography. We labor in that vineyard every day and most nights and we believe we can ably comment on the best ways to ensure timely

availability and rapid insertion of this technology into semiconductor production in the United States.

I cannot fully support the NACS recommendation on X-ray lithography.

The NACS Report seems to "me-too" the Japanese approach by emphasizing the expansion of synchrotron X-ray lithography research activity.

I strongly support the X-ray lithography research work being done by DOE and industry on the synchrotron at Brookhaven National Laboratory on Long Island, New York, the University of Wisconsin, and the work IBM and Motorola are doing at East Fishkill, New York.

However, it is my belief that there is real potential to leapfrog our foreign competition by pursuing the uniquely American concept of granular or modular X-ray lithography systems. While NACS supports work in what they term "small X-ray sources," they do not identify or address the potential of X-ray point sources.

Others are paying considerable attention to the role of X-ray point source steppers in making U.S. efforts in this field successful.

This progress, and the robustness and validation of this American approach to X-ray lithography deserve more recognition, support and emphasis in the recommendations of NACS concerning X-ray lithography.

The nation, or company that achieves breakthroughs in chip performance establishes a "first-to-market" position, and enjoys the economic rewards before large-scale use drives each new generation of ICs to commodity status, and to lower prices. The leader sets the world standards for all other IC suppliers, controls the distribution of new chips, and capitalizes on implementing the devices in commercial and military applications.

Lithography Systems: The Fine Line in Chip Making

Until laser-based soft X-ray lithography was introduced, semiconductor manufacturers were limited to optical or electron beam (E-beam) lithography to produce circuit designs. Today, optical systems account for the largest installed base of lithography systems, but it is X-ray lithography that holds the potential for the semiconductor industry to produce new generations of high-precision chips.

The first optical lithography systems were developed in the U.S. by Perkin Elmer. A major technological advance over those early systems were the optical steppers first developed in the United States by GCA Corporation. However, this market was later targeted for domination by two Japanese companies, Canon and Nikon, which today hold 70% of the

world market between them. This process of concentrated Japanese investment is made possible in large part by the lower cost, and greater patience of capital in Japan than has been available in the U.S. for 20 years.

A Turning Point in Technology Leadership

The decisions that the U.S. government and the U.S. semiconductor industry make today to commit resources for the production of advanced chips for world markets will have a powerful effect on the country's competitive and economic position in technology.

In the manufacturing process for semiconductor chips, the "printing" or lithography step is the most critical to the cost effective extensions of the industry into new generations of chips and systems.

The cost of developing and bringing to market a qualified computer chip "printing press" is between $75 million and $250 million. In order to play this game, a U.S. firm must have access to that kind of money at competitive rates, and then it must have the financial resources to commercialize the tool by having it tested to make it suitable for efficient semiconductor production.

This is not for the faint at heart. For example, in the seven years since our Company was founded, we have invested $58 million in product development -- $22.6 million of which has come from equity investors.

But even these far-sighted investors must play in the capital environment that has dominated our nation and stifled the commercialization of innovation here in the past two decades.

Hampshire is particularly proud of the support it is receiving from the State of New York. To the best of its ability, New York State is doing something about the cost of capital for promising technology companies.

Hampshire has also benefitted from inclusion in the forward-looking, but underfunded National X-ray Lithography Program.

DARPA has done an excellent job of managing what they have to work with, but this just has not been enough to fully support a national X-ray lithography initiative.

The bulk of funds appropriated to date have gone to synchrotron research and construction projects. This has left some room, but not much, for funding other aspects of a full scale national X-ray lithography effort.

Our federal appropriations commitment to this technology does not and cannot compete with the hundreds of millions our Pacific trading partners are spending, but it may not be necessary for us to compete dollar for dollar. We can be smarter, if not richer in our approach by appropriating sufficient funds to advance more than one promising approach to commercializing x-ray lithography--something the Japanese are not doing.

A Semiconductor Equipment Test-Bed Initiative:

Tomorrow's Equipment for Semiconductors Today -- "TEST"

At the beginning of my remarks, Mr. Chairman, I stated that the critical barrier to regaining our leadership in semiconductor equipment was the high cost of capital and that we need to utilize present mechanisms, already in place, to focus lower cost capital on a comprehensive test-bed program for American semiconductor capital tools in American semiconductor manufacturing plants.

The U.S. government needs to recognize the importance of this industry and this technology and needs to realize that the tool set -- or capital goods -- required for us to be competitive will not be available without first, access to capital at rates available elsewhere AND second, a test bed program, supported by adding new funds and dedicating these funds to "burn in" new tools, to make them production worthy on the American factory floor.

If we are to regain technological leadership in semiconductors, a nationally-supported test-bed program, for new generations of essential semiconductor capital equipment, is going to be the critical factor. At the cost of capital today in the U.S., such a test-bed program will not proceed with the necessary speed or quality and thoroughness without federal support.

The good news is that once the test-bed phase has been achieved, private industry will be more than capable of carrying the ball from there without more government stimulation--and will repay the investment not only in a robustly competitive industry and in new, high quality jobs, but in sizeable tax payments as well.

America's pre-eminence in world agriculture would never have been achieved without the homesteading program, land grant colleges, rural electrification, and government supported agricultural research. We would not have achieved supersonic flight, or commercial jet aviation without the government's support of facilities, prototypes and equipment devoted to Chuck Yeager and his colleague test pilots. Applying the same principles, we must provide affordable capital and government support to testing critical new generations of capital equipment on the factory floors of leading U.S. semiconductor firms.

I am proposing today a three-way partnership between the semiconductor companies, the leading edge capital equipment producers and the federal government. The test-bed host semiconductor manufacturers would support the cost of integrating test-bed capital equipment in their pilot-line chip fabrication areas. Capital equipment makers

would support the diagnostic engineering, engineering upgrades, reliability and quality testing, installation, operation and testing personnel--and would, of course, manufacture the test-bed machines. The government would purchase and furnish these machines to test-bed host companies as government furnished equipment (GFE).

The program I propose, Tomorrow's Equipment for Semiconductors Today (TEST), would significantly accelerate the insertion and qualification of equipment needed to regain world semiconductor leadership.

In the case of Hampshire, such a program would insure that the technology transfers and joint efforts we are engaged in now would quickly take wing and contribute to the pre-eminence of American integrated circuit factories.

We believe that the concept of a National Semiconductor Test-Bed Initiative is an excellent opportunity for our government to support what the Administration has called precompetitive research and development that can add value to our nation and restore leadership to a critical support beam in the very foundation of the American industrial base.

Thank you.

STATEMENT OF PETER H. MILLS, SENIOR VICE PRESIDENT, ADMINISTRATION, SEMATECH

Mr. MILLS. Thank you, Mr. Chairman.

As you know, SEMATECH is a unique $200 million government/industry consortium formed to restore this Nation's leadership in semiconductor manufacturing technology. SEMATECH's 14 members represent approximately 80 percent of America's semiconductor manufacturing base, who employ more than 700,000 Americans.

We have talked about the woes of the American industry versus Japan. Basically, SEMATECH was formed to help America regain its world leadership in technology. We are strictly an applied research project that is not product-specific. Our only product is knowledge. That has allowed us the freedom to try bold new processes and to embark on an ambitious schedule to produce critical technology.

I have been asked to talk about some of the successes of SEMATECH. To answer the question, "Is SEMATECH working?" I would answer with an emphatic yes. And I believe our members, two of whom are represented to my left here, would agree. SEMATECH has launched 44 joint development project, with equipment and material suppliers to the industry as part of the mission to restore preeminence to the U.S. semiconductor industry.

These projects are designed to achieve next-generation capability in the full spectrum of semiconductor equipment and materials, ranging from lithography to chemical and gas distribution systems. SEMATECH is working with these companies to ensure that we reach parity with the Japanese in semiconductor manufacturing in 1991, and surpass them in 1993.

One of our main thrusts at SEMATECH is in the area of optical lithography. In the past seven years, U.S. manufacturers' world market share has dropped from more than 70 percent to less than 20 percent. We are focusing our efforts on advanced stepping aligners, the key piece of equipment in the lithography process, by working to keep two U.S. stepper manufacturers viable, GCA/Ultratech and SVGL, each of whom employ a unique approach.

Our work with GCA/Ultratech has resulted in the introduction of a stepper which is two and a half times more reliable than GCA's previous model. We have placed five of these machines with our member companies for evaluation in production environments, and we are working with GCA/Ultratech on the next generation stepper which we believe will be available for evaluation later this year.

We were also pleased to have played a role in the creation of SVG lithography systems, which you mentioned in your opening remarks. SEMATECH has signed a joint development contract with SVGL for development of their next generation stepper.

We have also had significant success with ATEQ and its laser mask writer. With SEMATECH, ATEQ was able to develop a system at least three times faster than any existing commercial system in the world today.

With SEMATECH, LAM Research has developed a new tool in multilevel metalization, showing a 61 percent improvement in aspect ratio, versus the best previously available tool in the world.

In addition, our chemical reclamation research has resulted in savings to SEMATECH of more than $250,000 since January of this year. That will result in millions of dollars in savings within the industry. And we have similar programs in water purification and gas delivery.

Now, we have also been asked to speak to lessons learned. When SEMATECH was formed no one really fully understood the rapid erosion of the U.S. semiconductor equipment and materials industry. Just last year Japan surpassed American firms in semiconductor equipment and materials market share.

Let me give you an example. In 1982 the world leader in semiconductor equipment sales was Perkin-Elmer, a U.S. firm which, at that time, had worldwide sales in semiconductor-related areas of $162 million. Nikon at the time ranked 10th with $58 million in sales. By 1988, Nikon was first in semiconductor equipment sales with $521 million, while Perkin-Elmer dropped to seventh place with $205 million in sales.

VSLI research figures for 1989 indicate that Nikon and Canon of Japan shared 70 percent of the $1 billion stepper market worldwide.

Japanese firms also often delay selling their state-of-the-art equipment to American companies by as much as a year, placing U.S. manufacturers at a tremendous disadvantage. Last year at an industry conference, Dr. Yoshida of Nikon was asked if his company would provide its latest and best equipment to U.S. and European manufacturers on an immediate and timely basis. His reply was, "We will provide it when it is appropriate."

Japanese companies often purchase inferior products from Japanese firms in order to help those suppliers improve their products. U.S. manufacturers should be willing to do the same with U.S. suppliers.

In this vein, SEMATECH conducted more than 40 joint workshops with suppliers, manufacturers, government scientists, and academia in 1988 and 1989. U.S. equipment and material suppliers are doing their part as well. For every contract dollar that SEMATECH invests, the supplier typically puts in about $3. And we believe that is excellent leveraging of our funds.

The bottom line for a healthy, strong, viable U.S. semiconductor industry is we must have a healthy, strong, viable U.S. equipment and materials industry. SEMATECH will continue to look for opportunities to assist the equipment and material suppliers so they are not continually swallowed up by foreign interests.

Could SEMATECH do more? Certainly. It is obvious to us that SEMATECH is necessary but not sufficient. The National Advisory Committee's report sets out numerous proposals to strengthen the industry. SEMATECH agrees with those recommendations, including an expansion of our program.

Some areas that we believe cry out for more research include lithography, input materials, computer integrated manufacturing, and production modeling, costs, and things of that nature. Clearly, SEMATECH could contribute to those areas with an expanded program.

Obviously the decline of America's semiconductor industry is of great concern to us at SEMATECH. Through SEMATECH, the

Federal Government can send a very strong signal that this Nation will not simply close its eyes and be led down a path of domination by our foreign competitors. We can send a strong signal throughout the world that we will take the necessary steps to regain our rightful place as the world's leader in manufacturing.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF PETER H. MILLS, SENIOR VICE PRESIDENT, ADMINISTRATION, SEMATECH

Mr. Chairman and members of the committee, on behalf of SEMATECH, I appreciate your invitation to testify today on the steps necessary by government and industry to keep the U.S. semiconductor industry and its equipment and materials industries competitive.

Pursuant to the committee's request, I will discuss the extent to which SEMATECH is accomplishing its goal of helping to develop and deploy advanced manufacturing technology for the semiconductor industry. I will also discuss the lessons SEMATECH has learned about how to strengthen the U.S. semiconductor industry and the equipment and materials industries. Finally, I will address whether SEMATECH could expand to handle new responsibilities as recommended by the National Advisory Committee on Semiconductors (NACS).

As you know, SEMATECH is a unique government-industry consortium that was formed in August 1987 to restore this nation's leadership in semiconductor manufacturing technology. SEMATECH is composed of 14 member companies (AMD, AT&T, Digital Equipment, Harris, Hewlett-Packard, Intel, IBM, LSI Logic, Micron, Motorola, National Semiconductor, NCR, Rockwell, and Texas Instruments), which represent approximately 80 percent of America's semiconductor manufacturing base and more than 700,000 American jobs.

The members contribute a total of $100 million annually to SEMATECH, an amount roughly equal to 1 percent of their annual

semiconductor sales. The federal government, through the Department of Defense and its Defense Advanced Research Projects Agency (DARPA), also invests $100 million a year in the project. More importantly, the member companies are making some of their best and brightest engineers and scientists available to SEMATECH. I believe the fact that these companies, which traditionally are fierce competitors, would put aside those differences and work together for the common good of the industry and the country speaks volumes about their commitment to what we are doing. That spirit of precompetitive cooperation also is seen in the more than 130 semiconductor equipment and materials companies that have joined our sister organization known as SEMI/SEMATECH.

The Japanese Challenge

Semiconductors are a vital part of our national economy. In fact, the electronics industry now employs more Americans than the steel, automobile and aerospace industries combined. Semiconductors, or chips as they are commonly known, are the building blocks for all high technology products manufactured in the world today. From digital watches to microwaves to fax machines to computers to fighter aircraft, the key component is the chip. A ready and inexpensive supply of chips is essential to U.S. industry and to our national defense.

Until the 1980s, the United States was the world's preeminent producer of semiconductors. Since that time, however, U.S.

leadership has steadily eroded and the once dominant U.S. companies have been replaced by foreign manufacturers. Japan has largely driven the United States from the world DRAM (Dynamic Random Access Memory) market and has made substantial inroads in every other product area.

Members of this committee know all too well that the Japanese government targeted the semiconductor industry as a priority for manufacturing and provided it with a wide range of assistance, including a secure domestic market, financial aid, and de facto antitrust immunity. The Japanese government also sponsored a succession of joint government-industry R&D projects aimed at developing the most advanced semiconductors and technologies.

These efforts were accompanied by a massive production capacity expansion that drove the world DRAM price to unsustainably low levels. Bolstered by higher prices in their home market, Japanese producers dumped their product in the United States. Both Japanese and U.S. companies lost billions of dollars, but the great financial strength of Japanese conglomerates - backed by the government - enabled them to remain in the market while all but two U.S. firms were forced to withdraw from the DRAM business altogether.

U.S. semiconductor manufacturers have traditionally been very competitive. But the Japanese challenge was unlike any they had faced from other American firms. It was conducted by a handful of vertically-integrated companies, endowed with virtually unlimited financial support of their government. Although U.S. semiconductor

manufacturers spend a higher percentage of their revenues on R&D than any other industry, no company was in a position to individually match cooperative efforts of the Japanese firms.

The Creation of SEMATECH

As a result of the financial battering suffered by U.S. companies, American expertise began to lag behind that of the Japanese, particularly in critical manufacturing technologies. Clearly, a joint effort of a magnitude rarely, if ever, seen in the United States was needed to reverse this trend.

SEMATECH was formed in response to that challenge. The project was set up to develop the most advanced semiconductor manufacturing technology and skills in the world, and to transfer those skills and the knowledge to the member companies. SEMATECH and SEMI/SEMATECH benefit the entire electronics industry by conducting cost-efficient, non-duplicative research and development and making the results available to the suppliers, fabricators, and ultimately the end users.

SEMATECH is strictly an applied research project. It is not product-specific, nor does it involve production or marketing. Our only product is knowledge. That has allowed us the freedom to try bold new processes and to embark on an ambitious schedule to produce critical technology. If we try something and fail, we only fail once, not 14 times. When we succeed, we do so at a cost far more economical than would be the case if all of our 14 members

had undertaken the same or similar projects. We are time driven, not profit driven. We are focused on tasks better done by a consortium than by an individual.

Is SEMATECH working? I would answer with an emphatic, "Yes!" and I believe our members would agree.

SEMATECH's successes have been widely reported in the media. I would note that our program has been reviewed by no less than five government agencies (General Accounting Office, Congressional Research Service, Office of Technology Assessment, Advisory Committee on Federal Participation in SEMATECH, Congressional Budget Office) in the past 18 months. The consensus of those reports is that SEMATECH is working and deserves support from the federal government.

Let me give you a sampling of the comments about SEMATECH:

The GAO has written: "SEMATECH is seeking to leverage its resources by effectively using the skills and resources of its member companies, suppliers, U.S. universities and federal laboratories."

The Defense Manufacturing Board: "SEMATECH has shown that industry-led efforts requiring both monetary and intellectual investment provide the incentive for active cooperation."

The Advisory Council on Federal Participation in SEMATECH: "SEMATECH has scored important preliminary successes and developed a cooperative working relationship with the Defense Advanced Research Projects Agency."

SEMATECH has launched 44 joint development project contracts

with equipment and materials suppliers to the industry as part of the mission to restore pre-eminence to the U.S. semiconductor industry. These projects are designed to achieve next generation capability in the full spectrum of semiconductor equipment and materials ranging from range from such critical technologies as lithography to chemical and gas distribution systems. SEMATECH is working hand-in-hand with these companies to ensure that we reach parity with the Japanese in semiconductor manufacturing in 1991 and surpass them in 1993.

One of our main thrusts at SEMATECH is in the area of optical lithography, a central element of the semiconductor manufacturing process. U.S. companies pioneered this technology and the equipment needed to do it. As is the case with so many other elements of our industry in recent years, we have seen our once dominant position overtaken by foreign competitors who have refined the process. As recently as 1983, American companies controlled more than 70 percent of the lithography equipment market. But there has been a dramatic reversal of positions. U.S. world market share has dropped to below 20 percent. The Japanese now control access to leading-edge lithography equipment. Lithography is one of the foundations for cost competitiveness in a semiconductor fab. Since lithography equipment is so critical to the overall technical capability of the industry, SEMATECH is investing more than half of its development budget in this area. Our efforts have resulted in the introduction of the GCA Autostep 200, an advanced stepping aligner, which is the key piece of equipment in the lithography process. It is 2.5 times

more reliable than GCA's previous model. We have already placed five of these machines with our member companies for evaluation in production environments.

SEMATECH also has had significant success with ATEQ and its laser mask writer. Working together under a SEMATECH Joint Development Program, ATEQ was able to develop a system a least three times faster than any existing commercial system in the world today.

Recently, AT&T - one of our member companies - agreed to share a key ingredient used to make advanced semiconductors under the auspices of SEMATECH. AT&T Bell Laboratories invented a version of a chemical that allows chip designers to pack a greater number of circuits on chips than they can using current technologies. Under the agreement, AT&T will allow Olin Corporation to make and sell a chemical used to etch extremely detailed electronic circuitry on chips. This is a prime example of how SEMATECH has made a difference.

Another significant achievement has been made with our Computer Integrated Manufacturing program. This program has helped the semiconductor industry join the computer industry to produce common specifications and standards for development of our manufacturing systems. The SEMATECH member companies recently gave unanimous approval to a comprehensive set of architectural guidelines for our program. We just conducted the first working meetings of industry systems experts laying the technical groundwork for producing consensus specifications.

As a result of a SEMATECH joint development contract, Lam Corporation's ECR 3000 tool has leapfrogged to the next generation capability for multi-level metalization, a critical step in the semiconductor manufacturing process. Lam's tool has shown a 61 percent improvement in aspect ration versus the best previously available tool.

SEMATECH's Board of Directors, as well as SEMI-SEMATECH's Board, has approved a "Partnering for Total Quality" program to encourage constructive relationships within the semiconductor industry. One of SEMATECH's stated goals is to help change the arms-length, often adversarial relationships that exist between customers and suppliers in the semiconductor industry. In particular, this program will provide guidelines, methods, and training for implementing a total quality program. The program developed by SEMATECH is based on the Malcolm Baldrige National Award.

Our research into internal systems for water purification, chemical reclamation and gas delivery in our fab has resulted in some notable achievements, too. The chemical reclamation program, which reprocesses sulfuric acid, has resulted in higher purity, minimal disposal requirements and reduced environmental hazards. This program has resulted in savings of more than $250,000 to SEMATECH since January 1, 1990 and will, in turn, save the industry millions of dollars. The water purification program gives SEMATECH one of the best water quality systems in the semiconductor industry and our gas team has jointly developed a gas delivery system that

has resulted in higher purity, higher yield and lower cost. All of our member companies will benefit from these accomplishments.

The Scope of SEMATECH

Why is the work that SEMATECH is doing important? Japan calls semiconductors "industrial rice." Chips are the foundation for consumer electronics, for advanced electronics, and for computer and related industries. Japan has targeted the semiconductor industry, which America invented, and has forged a strategy designed to capture world leadership. Since launching its VLSI effort in 1975, Japan has surpassed America in semiconductors and, perhaps more alarmingly, just last year surpassed American firms in semiconductor equipment and materials for the first time.

That's not an accident. Japan has targeted that industry, too. But their strategy is a bit different. Since 1987, Japan has acquired 16 U.S. equipment and supplier firms. Twelve U.S. companies have been acquired by European firms, and 30 have been acquired by U.S. companies. Four U.S. equipment and materials suppliers have gone out of business. The erosion of a domestic infrastructure threatens to make U.S. semiconductor manufacturers dependent upon foreign suppliers, a trend that would not bode well for a competitive U.S. industry.

Let me give you an example. In 1982, the world leader in semiconductor equipment sales was Perkin-Elmer, a U.S. firm with worldwide sales of $162 million. Nikon, the Japanese giant, ranked

10th with $58 million in sales. By '988, Nikon had moved into first place in semiconductor equipment sales at $521 million while Perkin-Elmer dropped to seventh place with $205 million in sales. Despite Perkin-Elmer's increased revenues, the company was on the verge of going out of business or being sold to the Japanese. Interested American companies have been negotiating to purchase Perkin-Elmer's semiconductor operation and prevent transferring that technology to Japan.

Here is an example of what U.S. semiconductor manufacturers are up against. We have discovered that Japanese companies often delay selling their state-of-the-art equipment to American companies by as much as a year. Imagine the disadvantage our manufacturers face. At an industry conference in Hawaii this past year, Dr. Yoshida of Nikon was asked if his company would provide its latest and best equipment to U.S. and European manufacturers on an immediate and timely basis. "We will provide it when appropriate," Dr. Yoshida replied.

VLSI Research figures for 1989 indicate that Nikon and Canon of Japan shared 70 percent of the $1.03 billion stepping aligner -- or "stepper" (a critical part of the lithography process) market worldwide. You might be surprised to know that Nikon makes more money from the sales of its steppers than it does from the sales of its cameras. The rest of the world stepper market is shared by ASM Lithography of the Netherlands and Perkin-Elmer and GCA/Ultratech of the United States, an organization that was formed by the May 1 merger of two General Signal Corporation

entities, GCA and Ultratech.

You cannot have a healthy, strong, viable U.S. semiconductor industry without a healthy, strong, viable U.S. equipment and materials industry. Those companies are the seed corn for the chip industry. That's why SEMATECH and SEMI/SEMATECH have been so involved in working with the equipment and materials suppliers. SEMATECH will continue to look for other opportunities to assist the equipment and materials suppliers. We cannot sit back and simply watch this vital industry either dissolve or be swallowed up by foreign interests.

We have a self-admitted bias toward American equipment and materials companies. We have discovered that Japanese companies will often purchase inferior products from Japanese firms and then embark on an ambitious program to help those suppliers improve the standards of their products. Shouldn't we be willing to do the same? We think so. That's why we had more than 40 joint workshops with suppliers, manufacturers, government scientists and academia in 1988 and 1989 where we shared our view of the future as well as the information needed to focus suppliers on their own R&D expenditures. That's why SEMATECH engineers are working with equipment and materials firms to help them solve their problems and improve their products so they can compete worldwide. And that's why we focus so much attention on our Equipment Improvement Programs and our Joint Development Programs.

There is another advantage, too. For every contract dollar that the federal government and SEMATECH invest, the supplier puts

in three dollars. That's very good leveraging of our funds. In 1989, SEMATECH's external spending was about $108 million and will reach $130 million in 1990.

The Future of SEMATECH

The NACS report sets out numerous proposals to strengthen the semiconductor industry. SEMATECH agrees with those recommendations in principle, especially those that are not simply industry-specific, but can be applied to all businesses. The NACS also makes excellent specific recommendations to strengthen the U.S. equipment and materials industry and we endorse those as well. We believe it is essential to increase R&D activity for manufacturing tools, materials, and processes. Certainly SEMATECH could play a role in that kind of program.

The NACS recommends that DOD and the Department of Energy continue their funding for silicon R&D. We agree that the current levels of funding for this program should be maintained, if not increased, and the same applies to X-ray lithography research.

The principle thrusts of the SEMATECH program have been:

--To improve the availability, capability, reliability, and cost of production tools for American suppliers to the semiconductor industry.

--To improve the materials used in semiconductor manufacturing.

--To improve the manufacturing techniques and methods utilized

by U.S. manufacturing methods.

Could SEMATECH do more? Certainly. We have discovered that SEMATECH is necessary but not sufficient. Here are some areas that we believe cry out for more research and which we could undertake given an expanded program: lithography; input materials; CIM and production modelling; and costs.

The basic limitation in production of advanced devices lies in the lithographic capabilities. U.S. capabilities in this critical area have eroded rapidly over the past 5-10 years, relative to Japanese suppliers. This has been, and must continue to be, a major thrust area for SEMATECH. Included is technology on resists, resist processing, mask making, and exposure systems. Extensions into deep ultraviolet, electron beam, X-ray optics and granular X-ray exposure systems represent high-risk, high-return alternatives which need to be studied exhaustively for production worthiness. Of course, SEMATECH would continue its aggressive programs in the lithography areas of steppers, tracks, and metrology.

Significant progress has been made in the cleanliness of process gases and liquids (input materials) at point-of-use through filtration and reprocessing systems, leading to higher production yields. Expanding the use of these techniques throughout the industry requires further engineering of the equipment involved and has very high leverage in improving the competitiveness of the U.S. industry.

The economic payoff for the use of better factory control and

scheduling (CIM and production modelling) in achieving higher equipment utilization, and better process control to enhance yields can be enormous. Current systems are inadequate to the complex manufacturing processes in use today and projected for the future. Process and equipment models which have been experimentally verified will substantially reduce start-up costs and risks in establishing new production capability. These programs require expanded operation resources in software development and in factory operations for verification.

Equipment and facilities costs are major considerations in competitiveness in light of the lower availability and higher costs of capital in U.S. industry. Innovative approaches in equipment design and clean transfer modules must be pursued for their cost impact.

SEMATECH's mission is manufacturing technology. As such, we enter a process after its manufacturing feasibility has been demonstrated. Process technology is clearly enabling advances in manufacturing capabilities. Our primary goal is competitiveness, which can be expressed in terms of the performance, quality, reliability, and cost of the American-made semiconductor devices. Competitiveness will, in turn, enhance the support base of further R&D. Early investment will have great economic benefits for our nation. We have taken a position that at the end of our five years, we will evaluate the program and determine where it should go.

The decline of America's semiconductor industry is, obviously, of great concern to us at SEMATECH. This nation has allowed the

high value-add jobs to leave the country. The blame lies solely with U.S. industry and our government, not with any of our competitors. But we must realize the consequences of that action and be prepared to pay them.

Countries that control technology also control where the interesting research projects and resulting technology will be located. Countries that control technology also control the location of those important high value-add jobs. Those who control the technology can dictate to other countries which jobs they will have, the wages that can be paid, and ultimately, the standard of living.

If we continue to allow those jobs to shift from our shores, the United States will simply become a source of resources and cheap labor and low value-add jobs for other nations. That's not the kind of economic future we want for this great nation.

At the same time the United States is playing a critical role in ending the Cold War, we are locked in an Economic War. The consequences no less and our resolve to win should be no less.

Through SEMATECH, the federal government has sent a strong signal that this nation will not simply close its eyes and be led down a path of domination by our competitors. We are sending a strong signal throughout the world that we will take the necessary steps to regain our rightful place as the world's leader in technology.

I thank you for the opportunity to testify before you today.

Senator GORE. Thank you very much.

We have really had some excellent statements this morning. And I appreciate all of you coming here.

Just to follow up on one of your last points, Mr. Mills, when a Japanese equipment supplier chooses to delay by as much as a year the availability of state-of-the-art equipment to American companies, compared to the availability afforded Japanese companies, how does that decision get made, do you know?

Mr. MILLS. Well, they do not have laws, I do not believe, that mandate any such action. Nor do they have laws, as Mr. Parkinson referred to, in the area of import tariffs. But to borrow a line from your earlier statement, they simply do things that are in our view rather protectionist, although not necessarily legislatively mandated.

And we have seen this for the last 10 to 15 years, when they initially set on their course to achieve worldwide dominance in these areas. They will do whatever is necessary to accomplish that end. And that includes providing their best available equipment to their own national firms that will include buying selections that will be fundamentally closed to other markets.

And it has nothing to do with laws or legislation passed within the nation, but they have a very, very nationalistic pride and sense of cooperation between government and industry there that fosters those protectionist attitudes.

Senator GORE. Then it is all reported in the Japanese press with war metaphors and battle metaphors.

Mr. MILLS. They have not forgotten.

Senator GORE. Let me come back to you, Dr. Armstrong, and your Advisory Committee's report. I do not want to beat a dead horse, but let me just ask you formally, to your knowledge, has the Advisory Committee received a formal response from the President?

Dr. ARMSTRONG. No, we have not received a formal response. But I would add that, as Dr. Bromley indicated, we have had what the committee believes, up till now, are very fruitful private exchanges over the issues at hand and over the recommendation. But we have not had a formal response.

Senator GORE. Has the President told your group, either formally or informally, what his Administration proposes to do regarding the problems and issues you raised in the report?

Dr. ARMSTRONG. Directly from the President, as you know, no. But many of the recommendations that we have made have been discussed in detail with members of the Administration. And they have indicated to us support for them.

Senator GORE. In concept?

Dr. ARMSTRONG. In concept, and have in fact engaged in discussions as to how particular recommendations could be improved or made more executable.

Senator GORE. But, as yet, there has been no action in response, other than these words in the meetings?

Dr. ARMSTRONG. Well, the various statutes and regulations have not yet been changed, for example.

Senator GORE. Nor have any proposals been forthcoming for such changes?

Dr. ARMSTRONG. I believe that is right. Although as you heard Professor Bromley say, the nature of our discussions was such that we were asked for further input. And we are at work on that, and we intend to provide that.

Senator GORE. Yes, and I think that is encouraging. And I think there is still a chance the Administration will actually find the courage to do something. If I thought there was no chance, then this hearing would be designed in a very different way. But I think the opposition from Mr. Darman and Mr. Boskin and Mr. Sununu and others has been thus far too strong to overcome.

Dr. ARMSTRONG. Well, Senator, their comments on different recommendations are quite different. And you are correct that they have great difficulty with some of the recommendations. And as far as I can tell, there are none at all with others.

Senator GORE. Well, we shall see. I have the disquieting sense that the President himself is indifferent to the fate of the semiconductor industry when it comes to the requirement to actually do something.

Now your report emphasizes the closely linked fate of three industries making up the electronic food chain: those who make semiconductor manufacturing equipment, the chip makers themselves, and the electronics companies which use the chips. The report says, and I quote again, that "If the U.S. position in semiconductor devices, equipment and materials continues to deteriorate, the entire domestic electronics products industry will be at the mercy of foreign suppliers."

Putting on your IBM hat for a moment, do you agree with that point? If IBM becomes highly dependent on chips from a foreign competitor who also makes computers, is it likely that the competitor's computer division will get new chips before you do? And also, that the kind of delays strategically designed we heard about a moment ago will affect IBM? And will that situation, in turn, threaten IBM's ability to compete in computers?

Dr. ARMSTRONG. Well, the answer in general of course is yes, Senator.

One of the reasons why we have been very active, as you know, in activities to strengthen the infrastructure is that we want to have a choice of supply. As you know, we manufacture much of our own semiconductors, but we buy a great deal. We buy a great deal from domestic suppliers. And we buy around the world because we produce around the world.

But it is the case that you need to have early knowledge of leading edge chip designs in order to incorporate those in a competitive way into systems. And if one has to wait until something is sort of generally available on the market, either because you cannot get early access to it through cooperative arrangements, or because you were not making it yourself, you are likely to be at a competitive disadvantage.

Senator GORE. So even IBM is at risk if this trend continues?

Dr. ARMSTRONG. Well, we would feel very much at risk if the infrastructure that supports the semiconductor industry in the United States were to continue to deteriorate. And we have said that often.

Senator GORE. All right. Now the report says an R&D funding shortfall of $800 million over the next three years exists in the U.S. semiconductor and semiconductor equipment industries. And that is the cost of keeping American technology competitive. In your judgment, where are the most critical technologies in the semiconductor field, and what are the most serious deficiencies?

To put a focus on the question, if you were king for a day and had $100 million or more for extra R&D, which areas would you focus on first? From a long-term competitive view, where is it most vital that we, as Americans, concentrate our efforts?

Dr. ARMSTRONG. Well, the area of lithography, which has been mentioned many times already this morning, is one that is crucial. It does represent a large fraction of the critical steps that are required in making advanced chips. So I would like to see and my firm would like to see, and the National Advisory Committee would like to see more investment in lithography.

There are other areas, I would say, of tools. A very important area is the area in which you learn how to integrate different tools together into manufacturing clusters. Now that is an area in which SEMATECH is working. We very much support the expansion of the mission of SEMATECH, because there is this very substantial area of R&D which the U.S. tooling companies' revenue is not sufficient to fund.

So I would say the manufacturing clusters are very important to economies of scale in the generations of chips that are coming.

There are several areas of hot processing tools where the investment in R&D in the United States has not kept up with overseas competition. I should mention that there are some areas of tooling where U.S. firms are very strong and compete successfully around the world. And we need to keep them strong and help build a balance. That is my view, speaking now personally and not necessarily for the committee, although I think this view would be shared by many.

What we should strive for is a technological balance around the world. That is, we should not be dependent on one area of the world for all of our new technology or our new tooling. Neither, in my view, is it realistic to be entirely self-sufficient. We should be strong enough so that the playing field is level, and we have the access that has been spoken of before.

And there is indeed a shortfall in the funds required to have that technological balance.

Senator GORE. I want to invite our other witnesses to address that same question. If you had a set amount of additional money and you could choose the most critical technological areas on which to focus, where would you focus? Mr. Parkinson?

Mr. PARKINSON. Mr. Chairman, I would say the simulation and design tools. I think the most vital ingredient of a sustainable company is the ability to introduce new generations early, and if the United States can pick up the pace in introducing new generations of DRAMs, SRAMs and VRAMs, whatever the case may be, then we will recapture market share and that will drive the demand for these tools and other developments that are so vital. So I would say that is where it all starts, right there in that R&D design phase.

I know, talking to DARPA, that they are extremely concerned that the Japanese are gaining increased momentum and strength in that arena of basic research, which again Senator Rockefeller alluded to, and I see that as one of our top priorities and concerns.

Senator GORE. Of course, again, DARPA has been decapitated.

Mr. PARKINSON. Yes. It was Craig Fields who was spearheading that.

Senator GORE. It was Craig Fields who was taking the lead on that, and that made the President nervous. Mr. Mills?

Mr. MILLS. I would repeat the areas which Dr. Armstrong mentioned: lithography and cluster tools. Specifically, in the area of lithography I am not sure you could ever reach saturation as to what is required there.

I mentioned in my opening remarks optical lithography. We are also engaged in a parallel effort in X-ray lithography, and you could probably double the size of our program and not spend enough money in those areas to really adequately cover what is required to be covered there.

There is one other point I would like to make in terms of the shortfall that the report points out. As an industry, the semiconductor group spends more, percentagewise, on R&D than any other industry, and yet we are faced with this tremendous disadvantage because of the inextricable relationship to lost market share. As market share declines, the available dollars for R&D decline as well, and you cannot take the risks. That is why we think that something like SEMATECH is so critical. If we try something the economies in success are enormous. If we fail, we have only failed one time rather than fourteen times.

Senator GORE. Dr. Lubin?

Dr. LUBIN. Senator, I think it is an issue not so much of specific tools as horizon.

Senator GORE. As what?

Dr. LUBIN. As horizon. I think we are forced by economic exigency right now to focus on the near term, to fight today's battles today, because if you do not come out at least even there is not going to be a tomorrow, and in fact that is much the mission of SEMATECH.

There is precious little activity going on that is concerned with the next five to ten years, and if we continue in this mentality, that we first have to get through the next two or three years—and you know every game plan comes out not exactly as planned, but somewhat marginal—then we will continually be in this two or three year look-ahead, and not the five, six or seven year robust look-ahead. That has really beaten the socks off us when it comes to long-range planning by our competition.

Traditionally, that function has been served by the defense industry and defense research in this country, but times are changing as we all know. I think we have to fill that gap with a five, six and seven year industry look ahead, and with these structures that will not just concentrate on research and development but concentrate on implementation.

Senator GORE. Very good.

Mr. Mills, the Committee recommends—the Advisory Committee recommends increased funding for SEMATECH, and we have

heard from you this morning and on other occasions that SEMATECH is working well, but are the participating companies showing any willingness to increase their funding in the consortium since the report was issued six months ago? Have any companies in fact offered to increase their funding of SEMATECH as was recommended? Is everybody waiting for a signal from the Government before that occurs? Has there been any increased private funding?

Mr. MILLS. As you are aware, it is basically a matching program—$100 million from Government, and just a little in excess of that from industry. We did not seek to expand our program. We have a considerable amount to say grace over today, but since the report came out we have taken a hard look at areas that we would consider if the program were to be expanded. There has not been any great discussion of considerable length at our board meetings as to whether or not the industry should step up to the plate first and submit additional funds or not, and I would say that it would be interesting to see the response from the Administration to the recommendations in that report before we take such action.

Senator GORE. Did you want to comment?

Dr. ARMSTRONG. Senator, if I might. It is my belief, and I think it is shared by many of my colleagues on the National Advisory Committee, that if there were to be a response from the Administration on this recommendation that certainly many of the members of SEMATECH would follow suit.

Senator GORE. Would follow suit?

Dr. ARMSTRONG. Yes.

Senator GORE. But not until then? As a practical matter it is not going to happen until the Government puts up its share?

Dr. ARMSTRONG. I think that is right.

Senator GORE. Mr. Parkinson, your company is also a member of SEMATECH. Has it been a good investment from your point of view for Micron? Have you gotten your money's worth from it?

Mr. PARKINSON. Well, Senator, there is no way to evaluate whether you get your money's worth, but I would say in answer to that that I cannot answer directly with a yes or no. There is always mixed feelings, but I will say, speaking for myself personally and on behalf of Micron, it is like having this Committee hearing. It focuses attention on vital issues; that collecting, you know, the leaders, the 14 largest semiconductor companies in one room has had an electric effect, I would say, on the industry, in focusing attention, getting us to work better together not only at SEMATECH but in other arenas.

IBM and Micron are now working together on DRAMs, and I would say that we also have worked together with other members on other issues, and that these are intangibles. The other thing that Peter alluded to are the workshops, you know, to just sit down and decide are we going to spend money on photolithography and in what ways?

You sit down and compare notes on your experience on various items of equipment, and when you think about an item in planning costing $1 million, and maybe running $2 or $3 million worth of wafers to evaluate it, each of us was spending $4 million per evaluation, probably, and comparing notes has saved us an enormous amount of money.

So I would say in evaluating the impact of these programs, those are the issues that need to be taken into account, and from that standpoint just the revival of the spirit makes it worthwhile.

Senator GORE. We have some developments on the floor that I will have to attend to.

I think it has been an unusually productive hearing. It has been interesting and valuable not the least because of the thoughtful statements you have made. On behalf of the subcommittee, I want to thank all of you for participating here today, and with that our hearing will stand adjourned.

[Whereupon, at 11:34 a.m., the subcommittee adjourned.]

[The following information was subsequently received for the record:]

STATEMENT OF EDWARD BRUAN, CEO AND PRESIDENT, VEECO INSTRUMENTS INC.

Good morning, Mr. Chairman, my name is Ed Braun and I am the President and CEO of Veeco Instruments, a US manufacturer of test instruments and precision capital equipment. One of our major customers is the worldwide semiconductor industry. I am also the chairman of SEMI's Government Relations Committee. I want to thank you for the opportunity to address you this morning.

SEMI represents approximately 850 US manufacturers (See Chart #1) located throughout the United States who are part of the $15B worldwide industry producing critical equipment and materials to the semiconductor device industry. Our companies provide the core manufacturing technologies for next generation semiconductor device production, which drives our leading edge computer, telecommunication, consumer and military electronics products. As you know, the US electronics industry is approximately $230B in size, employs more Americans than any other US industry, has a higher growth rate than any US industry, and is a leading exporter to Europe, Japan and the Pacific Rim.

Mr. Chairman, a great deal of concern has already been voiced by both industry and government authorities regarding the eroding competitiveness of both the semiconductor device industry and its supplier base. There are already a number of important initiatives underway to address these trends through collaborative efforts between the U.S. equipment and materials vendors, their customers, and the U.S. Government, such as SEMATECH and DARPA's x-ray lithography program. However, we believe more needs to be done.

Despite the positive overall growth of our industry, the dominance of US companies has declined significantly in our industry during the past 10 years (see attached Chart #2).

If we, industry and government, allow the erosion of our leadership in core technology areas to continue, we will indeed enter the year 2000 manufacturing potato chips rather than computer chips and we will have lost an important base of technology. Why does this matter? Because the products we manufacture have a far-reaching effect on our future economic growth and standard of living. Electronics is the motor which drives future development in a host of other industries.

The decline of US leadership in electronics is undeniable, but it is repairable. We must recognize, however, that there are no quick fixes, and that two significant factors have changed over the past 10 years:

1. This has become a global business (In 1980, 80% of our industry's sales were in the US; today, only 50% of our sales are in the US). As Chart #3 shows, the majority of our industry's market now lies outside the United States. Success in the 90's demands an ability to develop leadership products and to market them aggressively overseas.
2. We no longer compete with companies, we compete with the outcome of focused government/industry initiatives. With the exception of the US, the world's major and emerging governments in Japan, Europe, and the Pacific Rim have identified this combination of electronics, computer and

semiconductor technology as critical to their future economic well being. As such, they are funding large-scale programs that combine government and industry resources on focused objectives, in semiconductor devices, semiconductor equipment, as well as telecommunication and computer products.

Obviously, there is not a single answer to reversing the erosion of our US competitiveness and 5 minutes isn't much time, but I would call your attention to 3 major areas of concern.

Increased Capital Investment

We must develop more patient, low cost US capital for this industry. US companies experience the cost of capital that can be paid by their major international competitors. A recent study by the Federal Reserve Bank of New York revealed that the rate of return required to cover financing for R&D projects in the US was 20.3% as compared to 8.7% in Japan or 14.8% in West Germany.

Favorable tax treatment of long term capital gains, R&D and investment, and accelerated depreciation schedules for semiconductor equipment, are obvious limited solutions, but we must be more creative.

Our market is global, our customers are global, and the formation of capital is global. If international investors place a higher value on our technology than we do, the answer is not to

prevent their much-needed investment. In its report on the semiconductor industry, the National Advisory Committee on Semiconductors (NACS) recommended that we should not restrict foreign investment other than for reasons of national security. SEMI concurs with this recommendation, and believes that our goal should be to increase levels of US investment in this industry, not to impose constraints on foreign investment.

I will share with you the difficulty of the US investment attitude towards our industry.

My company, Veeco Instruments, grew as a US company from 1945 to 1989 to a size of $280M and was listed on the NY Stock Exchange. In 1989, Veeco was purchased by an English conglomerate, Unitech PIC as part of their strategic investment in electronic power supply products.

In January 1990, I led a management purchase of our instrument and capital equipment groups, backed by US banking and venture capital. Veeco Instruments is today a private, US-owned instrument company.

But I should note that in the year it took to raise this capital...it was apparent that Europe and Asia were sources of more patient, low cost capital, and that in the US it was clearly necessary to create a business plan describing my company as medium technology rather than high technology and that minimizing our dependence on a semiconductor customer base was critical in gathering investors.

We must improve the US attitude toward critical high technology industries, and we must stop emphasizing short-term financial results. Our European and Japanese counterparts report financial results every 6 months, rather than every 3 months; typical of a more patient long term investor attitude.

Increased Export and International Trade

Our customer base is clearly worldwide and we enjoy significant exports to Europe, Japan and the Pacific Rim.

Yet, despite growing foreign availability of our products, and the export reforms mandated by the Omnibus Trade and Competitiveness Act of 1988, the US government has refused to eliminate licence requirements for West/West CoCom trade. The result, Mr. Chairman, is that last year the Commerce Department processed 28,000 unnecessary licenses to trade with our western CoCom allies. The cost to the US taxpayer, and to our member companies, and the restriction this places on timely trade is foolish. Our government continues to emphasize the need for EXPORT CONTROLS, while the rest of the world's governments clearly encourage increased TRADE as part of their economic growth.

Overly restrictive export regulations must be eliminated if US companies are to succeed in the 1990's.

The irony in the policies of today's Administration is that while we cannot arouse belief that we are strategic to the

economic future of the US, we have no trouble being recognized as strategic for purposes of export control regulations.

As Dr. Sheldon Weinig recently said when he was selling Material Research Corporation to SONY..."Why am I only viewed as a national treasure when I am selling my company...where was this government interest when I was running my company?"

Increased R&D Funding of Critical U.S. Technologies

Our trading partners have recognized that the semiconductor equipment and materials industry is the crucial infrastructure that enables leadership in semiconductors, computers, telecommunications, and consumer electronics. Focused government sponsorship of critical technologies can have dramatic impact. Witness the developments in semiconductor manufacturing in Japan which are a legacy of the Japanese VLSI program.

SEMATECH and other semiconductor-oriented federal R&D programs in the US are to be encouraged as a very positive example of industry/government collaboration. But their funding is minuscule in comparison to the multi-billion dollar European JESSI program or the Japanese SORTEC program in x-ray lithography.

Semiconductor equipment research and development costs are far higher than the typical FORTUNE 500 industrial companies. SEMI members often spend 15% of their sales revenues on costly product development. One industry analyst has noted recently

that established equipment manufacturers typically spend 40 times an equipment's selling price to develop a new system. (VLSI Research, 1989.) In the US, the equipment vendors often carry the full burden of this R&D cost, whereas overseas these costs are often shared with the customer.

In addition, short product life cycles and rapid technology changes put further strain on industry profits and return on investment. Strategic company alliances, consortia, and combined industry/government programs are an effective solution to improving U.S. competitiveness.

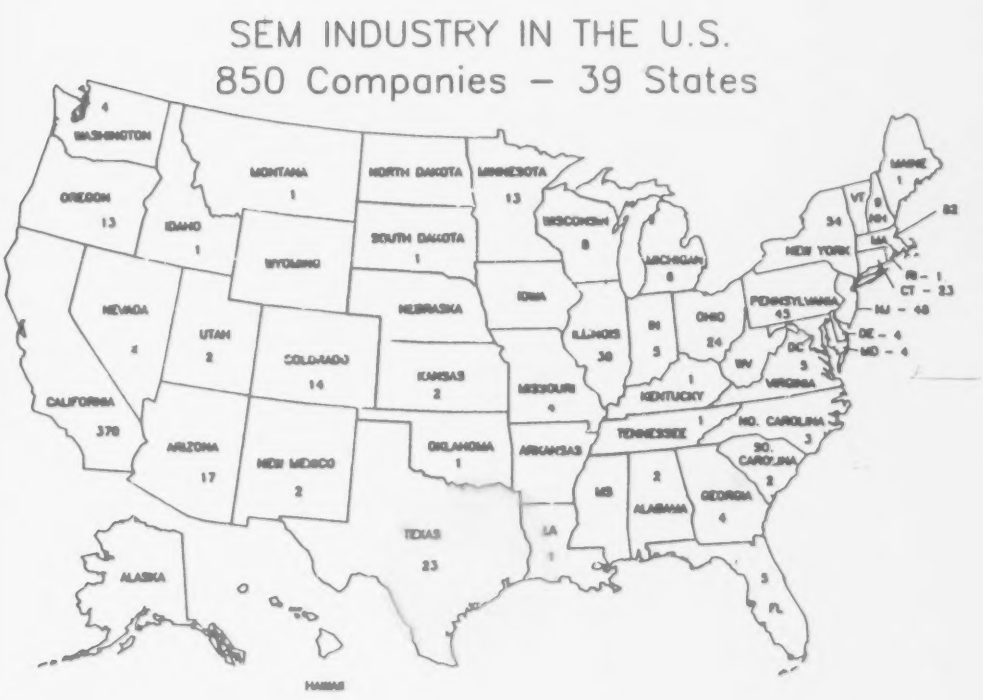
Conclusion

Increased US competitiveness in the semiconductor industry and its infrastructure will result from well-defined leadership products, marketed on a worldwide basis with free access to Japan, Europe and the Pacific Rim countries. Government restriction of trade, restriction of capital flows and restriction of exports is not a solution. We need government's proactive support of the growth of our industry through focused government efforts to reduce the cost of capital, support critical R&D, curb the emphasis on short term investment, and to assist industry in export promotion.

Semiconductor electronics are at the very heart of future consumer, industrial and military products. To abandon this

field is to put at risk our future economic, military and political security.

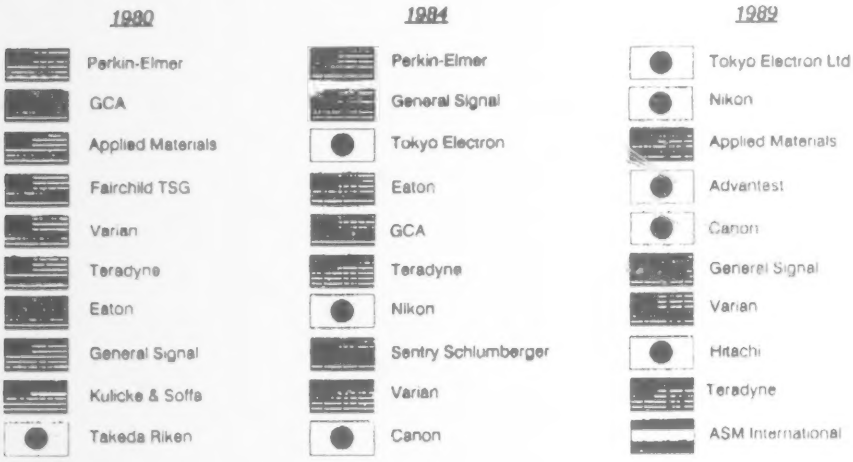
Thank you Mr. Chairman, for this opportu ity to offer my views. I would be happy to answer any questions you might have.



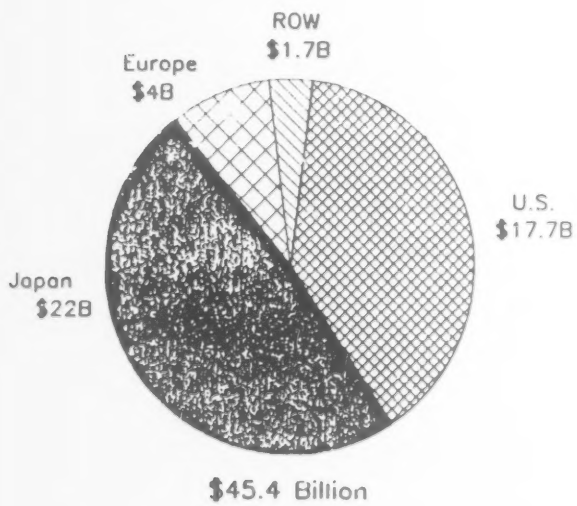
SEMI

Top Ten

Semiconductor Equipment Manufacturers



Distribution of World Semiconductor Production by Base of Producer



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Source: QFA, WSTS